Instruction MANUAL

SERIES 20 PULSE GENERATOR

Models P22/P24

INTERSTATE ELECTRONICS CORPORATION
A Subsidiary Of A-T-O Inc.
Department 7000 707 EAST VERMONT AVENUE, ANAHEIM, CALIFORNIA 92803 • (714) 772-2811

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Model No. _____ Serial No. _____

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Part No. P00336099-2 (P22/P24)

WARRANTY

Interstate Electronics Corporation warrants its function generators against defects in material and workmanship for a period of one year from date of shipment. We will repair or replace defective products during the warranty period provided that such defect developed under normal and proper use and that transportation costs are paid by the purchaser. We are not liable for consequential damages nor is any other warranty expressed or implied.

RECEIVING AND INSPECTION

Immediately upon receipt of the instrument, inspect the exterior of the shipping container for physical damage and notify carrier if such damage is visible. After carefully removing all packing materials, inspect the instrument to ensure that it is free of mars and blemishes.

CLAIM FOR DAMAGED SHIPMENT

If damage has occurred, a claim should be made with the carrier. The claim agent should receive a complete report of damage and a copy of the report should be sent to IEC. After receiving this report, IEC will advise you of the disposition of the instrument and arrange for its repair or replacement.

POWER

This instrument operates from a-c power only, either 115 or 230 vac, 50 to 400 Hz. A slide switch at the rear of the equipment readily selects the desired power line voltage.

CAUTION

Operation at the wrong power line voltage switch setting may damage the instrument.

PERFORMANCE TESTS

Electrical performance tests should be concluded as soon as possible. See paragraph 4-2, Section 4.

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Section 1
SPECIFICATIONS AND INSTALLATION

1-1. INTRODUCTION

This manual has been prepared to complement your Interstate SERIES 20 Pulse Generator by providing data on its operation, maintenance, and performance. Although this manual is intended as an aid for the user as well as the calibration or maintenance technician, every effort has been made to design the pulse generators so that constant reference to this manual is not required to operate the equipment.

1-2. RECEIVING AND INSPECTION

Immediately upon receipt of the instrument, inspect the exterior of the shipping container for physical damage and notify the carrier if any damage is visible. After carefully removing all packing materials, inspect the instrument for dents or mars and confirm that the electrical performance meets or exceeds the specifications as soon as possible. Paragraph 4-2 in Section 4 contains a suggested receiving performance test procedure that may be used.

1-3. INSTALLATION

This instrument may be used on the workbench or it may be rigidly mounted in a RETMA rack structure by means of an optional rack mounting kit. As initially shipped in the bench-use configuration, the instrument has a bottom-mounted tilt mechanism that must be removed for proper rack mounting. Detailed installation instructions of this feature are provided with the rack-mount kit.

This all solid-state instrument requires no special cooling facilities except that care must be taken to ensure that a 2-inch minimum clearance is provided at the rear of the instrument for proper convection cooling.

1-4. POWER REQUIREMENT

This instrument operates from a-c power only from 48 to 440 Hz. Normal input voltages of 115 or 230V ac ±10% may be selected by a rear-panel slide switch. If lower than normal voltages are available (100 or 200V ac ±10%) the FINE ADJ slide switch should be placed in the LOW position.

NOTE

Be certain to check that the correct fuse is installed for the line voltage selected.

CAUTION

Operation at the wrong power line voltage switch setting may damage the instrument.

A three-conductor line cord is supplied with the equipment to permit referencing the chassis and case to power system ground. This safety feature is recommended by the National Electrical Manufacturers Association (NEMA). The offset pin on the power cord connector is the ground wire.

1-5. REPACKAGING

If it becomes necessary to pack the instrument for shipment, the following procedure is recommended:

a. Attach a tag bearing the owner's name, address, and telephone number together with a brief description of the purpose of the shipment and the date its return is desired.

b. Wrap the equipment in heavy paper or plastic before placing it in an inner container.

c. Liberally use soft packing material around all sides of the instrument inside the inner container.

d. Enclose the inner container in a rugged carton or wood box with suitable packaging material to prevent movement in any direction and seal the outer container with heavy tape or metal bands.

e. Mark the shipping container with the shipping address and "DELICATE INSTRUMENT" labels.

1-6. DISASSEMBLY

To remove the pulse generator from its case, remove the four 6-32 retaining screws from the bottom of the case and slide the electronics forward.

1-7. SPECIFICATIONS

The following data sheets provide the specifications on the P22 and P24 pulse generators. While these data sheets represent the most accurate information available at the time of publication, Interstate reserves the right to modify the specifications at any time.

P22 PULSE GENERATOR

NEW PRODUCT NEWS

- Pulse repetition rates and squarewaves to 50 MHz
- 10-nanoseconds to 1-second width and delay adjustments in 100:1 ranges
- Single output, selectable positive or negative pulse with d-c offset
- Fast 3.5 nanosecond rise/fall times
- 10 v pulses into 50 ohms; 5 v with 50-ohm source and load
- Exclusive Constant Duty Cycle mode
- Normal, double pulse, trigger, triggered double pulse, gate, and amplifier modes
- Trigger and gate with slope and level controls
- All controls and indicators on front panel

The Interstate P22 Pulse Generator, offering a fixed 3.5 nanosecond rise time, is a precision human-engineered source for high-speed logic tests and other pulse generator applications.

Exceptional features include a single mode control for any one of seven operating modes, and a unique Constant Duty Cycle mode. In the latter, the width control establishes a timing ratio (duty cycle) between pulse width and period that remains constant as rep-rate is varies. Also included are 100:1 continuously adjustable controls for rep-rate, width, and delay, with log-taper characteristics for maximum resolution. Improved rep-rate setability is provided by a separate 10:1 coarse/fine vernier.

This SERIES 20 Pulse Generator is designed for operating ease and simple maintenance. The single circuit board is constructed with plug-in dual in-line ICs, with all components and internal calibration points fully accessible. All outputs are short-circuit protected and, together with all the input and operating controls, are located on the front panel. Output transistors are socket-mounted for easy replacement, if required.

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P22 PULSE GENERATOR SPECIFICATIONS

PULSE CHARACTERISTICS

Polarity: Single channel output, switchable positive or negative going with separately adjustable Offset and Amplitude. Will withstand direct short to ground without damage.

Repetition Rates: 1 Hz to 50 MHz, in 4 ranges with continuously adjustable coarse and fine vernier adjustment 100:1 adjustment on lowest 3 ranges; 50:1 on 50-MHz range.

Width: < 10 nanosec to 1 sec in 4 ranges with continuous 100:1 adjustment in any range.

Delay: Adjustable from < 10 nanosec to 1 sec with respect to Sync output in four ranges with continuous 100:1 vernier adjustment in any range.

Amplitude: Separate 10, 5, and 1 v ranges with continuous > 10:1 adjustment in any range.

Output Impedance: 50Ω, constant for any amplitude vernier setting on 1 and 5 v ranges; internal 50-Ω source disconnected on 10 v range.

Rise/Fall Times: < 3.5 nanosec (fixed).

Duty Cycle: > 75% for rates to 10 MHz, decreasing to 50% at 50 MHz, all modes except Constant Duty Cycle (CDC). In the CDC mode, duty cycle is continuously adjustable from 5 to 95% up to 1 MHz, decreasing to 50% (squarewave format) at 50 MHz.

Abberations: Overshoot, preshoot and ringing < 5% of pulse amplitude.

Jitter: Rate, delay, and width jitter < 0.1% + 50 picosec.

OFFSET:

Positive polarity pulse adjustable +1 to -6 v; negative polarity pulse adjustable -1 to +6 v independent of attenuator setting (disabled on 10 v attenuator setting).

MODES:

Normal: Internal clock provides trigger for standard delay and width functions.

CDC Mode (Constant Duty Cycle): Duty cycle of pulse set by Width vernier as percent of pulse period and maintained essentially constant over entire pulse rate range. Duty cycle continuously adjustable from 5 to 95% of period with pulse rates to 1 MHz, decreasing to 50% duty cycle at 50 MHz.

Double Pulse: Provides two pulses for each generator cycle. Pulses separated by Delay period. Maximum effective rate is 50 MHz (Internal clock at 25 MHz.)

Trigger: Manual or external trigger > 0.7 v p-p, 35 v maximum, at Trigger Input generates one complete pulse cycle. Threshold adjustable ±5 v with Trigger Level control. Trigger Slope switch selects positive or negative going edge of external signal. Input impedance is 1 k in parallel with 15 pf.

Gate: Manual or external signal at Trigger Input enables generator for duration of applied signal. Last cycle completes itself even if gate is removed in mid-cycle.

Triggered Double Pulse: Same as triggered pulse except two pulses separated by Delay period are initiated with each trigger command.

Pulse Amplifier: External waveform applied to input BNC connector is squared and applied directly to output amplifier. Offset and Amplitude controls may be independently adjusted as in Normal mode. Also may be actuated with Manual trigger.

Trigger Light: Glows whenever internal clock or external trigger is providing adequate trigger to following circuits and SYNC output. Will blink at extremely slow trigger rates. In CDC MODE light goes out if pulse width settings are either too narrow or too wide for proper operations.

AUXILIARY OUTPUTS:

Sync Out: Nominal 0 to +2.5 v into open circuit (TTL compatible), rise/fall < 5 nanosec, output impedance is 50 Ω Squarewave except in CDC mode where duty cycle is identical to main output and external modes where duty cycle is identical with external drive signal.

Clock Out: Nominal 0 to +2.5 v into open circuit (TTL compatible), rise/fall < 5 nanosec, output impedance is 50Ω. Squarewave in all modes, coherent with main output in Normal and CDC modes, and during Gate interval. Nonsynchronous free-running in Trigger and Pulse Amplifier modes.

POWER: 10, 115, 200 or 230 vac ±10%. Switch selectable, 48 to 440 Hz, 75 w max.

OPERATING TEMPERATURES: 0° to 50° C.

DIMENSIONS: 17" wide x 3-1/2" high x 13-1/2" deep.

WEIGHT: 15.5 lb., Net

NOTE: Except where otherwise noted, all specifications apply with 50-Ω resistive load, 5 v output level, zero offset, amplitude verniers full CW.

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P24 PULSE GENERATOR

NEW PRODUCT NEWS

- Pulse repetition rates and squarewaves to 50 MHz
- 10-nanoseconds to 1-second width and delay adjustments in 100:1 ranges
- Single output, selectable positive or negative pulse with d-c offset
- Independent variable rise/fall times from 5 nanoseconds to 0.5 seconds
- 10 v pulses into 50 ohms; 5 v with 50-ohm source and load
- Exclusive Constant Duty Cycle mode
- Normal, double pulse, trigger, triggered double pulse, gate, and amplifier modes
- Trigger and gate with slope and level controls
- All controls and indicators on front panel

The Interstate P24 Pulse Generator is a highly flexible pulse source for general laboratory application. The P24 provides a positive or negative adjustable rise/fall pulse, with independently variable rise/fall controls.

A single mode control selects any one of seven operating modes, including a unique Constant Duty Cycle mode. In the CDC mode, the Width control establishes a timing ratio (duty cycle) between pulse width and period that remains constant as rep-rate is varied. Also featured are 100:1 continuous adjustments for rep-rate, width, delay, and rise/fall, with log-taper resolution for maximum control. High resolution rep-rate setability is provided by a separate 10:1 fine tuning vernier.

This SERIES 20 Pulse Generator is designed for operating ease and simple maintenance. The single circuit board is constructed with plug-in dual in-line ICs, with all components and internal calibration points fully accessible. All outputs are short-circuit protected and, like the input and the operating controls, are located on the front panel. Output transistors are socket-mounted for easy replacement, if required.

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P24 PULSE GENERATOR SPECIFICATIONS

PULSE CHARACTERISTICS

Polarity: Single channel output, switchable positive or negative going with separately adjustable Rise/fall times, Offset, and Amplitude. Will withstand direct short to ground without damage.

Repetition Rates: 1 Hz to 50 MHz, in 4 ranges with continuously adjustable coarse and fine vernier adjustment, 100:1 adjustment on lowest 3 ranges; 50:1 on 50-MHz range.

Width: <10 nanosec to 1 sec in 4 ranges with continuous 100:1 adjustment in any range.

Delay: Adjustable from <10 nanosec to 1 sec with respect to Sync output in four ranges with continuous 100:1 vernier adjustment in any range.

Amplitude: Separate 10, 5, and 1 v ranges with continuous >10:1 adjustment in any range

Output Impedance: 50 Ω, constant for any amplitude vernier setting on 1 and 5 v ranges: internal 50-Ω source disconnected on 10 v range.

Rise/Fall Times: Adjustable from 5 nanosec to 0.5 sec in 4 ranges with separate 100:1 vernier adjustments of rise and fall times. Rise and fall times are linear to >95% between 10 and 90% points for times > 30 nanosec.

Duty Cycle: >75% for rates to 10 MHz, decreasing to 50% at 50 MHz, all modes except Constant Duty Cycle (CDC). In the CDC mode, duty cycle is continuously adjustable from 5 to 95% up to 1 MHz, decreasing to 50% (squarewave format) at 50 MHz.

Abberations: Overshoot, preshoot and ringing < 5% of pulse amplitude.

Jitter: Rate, delay, and width jitter <0.1% + 50 picosec.

OFFSET:

Positive polarity pulse adjustable +1 to -6 v; negative polarity pulse adjustable -1 to +6 v independent of attenuator setting (disabled on 10 v attenuator setting).

MODES:

Normal: Internal clock provides trigger for standard delay and width functions.

CDC Mode (Constant Duty Cycle): Duty cycle of pulse set by Width vernier as percent of pulse period and maintained essentially constant over entire pulse rate range. Duty cycle continuously adjustable from 5 to 95% of period with pulse rates to 1 MHz, decreasing to 50% duty cycle at 50 MHz.

Double Pulse: Provides two pulses for each generator cycle. Pulses separated by Delay period. Maximum effective rate is 50 MHz (Internal clock at 25 MHz)

Trigger: Manual or external trigger > 0.7 v p-p, 35 v maximum, at Trigger Input generates one complete pulse cycle. Threshold adjustable ±5 v with Trigger Level control. Trigger Slope switch selects positive or negative going edge of external signal. Input impedance is 1 kΩ in parallel with 15 pf.

Gate: Manual or external signal at Trigger Input enables generator for duration of applied signal. Last cycle completes itself even if gate is removed in mid-cycle.

Triggered Double Pulse: Same as triggered pulse except two pulses separated by Delay period are initiated with each trigger command.

Pulse Amplifier: External waveform applied to input BNC connector is squared and applied directly to output amplifier. Rise/fall, Offset and Amplitude controls may be independently adjusted as in Normal mode. Also may be activated with Manual trigger.

Trigger Light: Glows whenever internal clock or external trigger is providing adequate trigger to following circuits and SYNC output. Will blink at extremely slow trigger rates. In CDC MODE light goes out if pulse width settings are either too narrow or too wide for proper operations.

AUXILIARY OUTPUTS:

Sync Out: Nominal 0 to +2.5 v into open circuit (TLL compatible), rise/fall <5 nanosec, output impedance is 50 Ω. Squarewave except in CDC mode where duty cycle is identical to main output and external modes where duty cycle is identical with external drive signal. Occurs in all modes of operation.

Clock Out: Nominal 0 to +2.5 v into open circuit (TLL compatible), rise/fall <5 nanosec, output impedance is 50Ω. Squarewave in all modes, coherent with main output in Normal and CDC modes, and during Gate interval. Nonsynchronous free-running in Trigger and Pulse Amplifier modes.

POWER: 10, 115, 200 or 230 vac ±10%. Switch selectable, 48 to 440 Hz, 75 w max.

OPERATING TEMPERATURES: 0^{o} to 50^{o} C.

DIMENSIONS: 17" wide x 3-1/2" high x 13-1/2" deep.

WEIGHT: 15.5 lb., Net

NOTE: Except where otherwise noted, all specifications apply with 50-Ω resistive load, 5 v output level, zero offset, amplitude verniers full CW.

INTERSTATE ELECTRONICS CORPORATION

Section 2
OPERATING INSTRUCTIONS

2-1. INTRODUCTION

As shown in figure 2-1 there is a high degree of commonality between the P22 and P24 pulse generators. Refer to the individual specification sheets for the detailed differences between the models.

An important design consideration for the SERIES 20 Pulse Generators was to maximize the ease with which the generators may be used with other equipments. Accordingly, all models are supplied with a full set of conditioning controls for any external input signal. Further, all of these controls are located on the front panel: There are no operating controls on the rear panel. The line-voltage selector switches on the rear panel permit the user to adjust to a wide range of line voltage conditions.

2-2. OPERATING NOTES

a. USE WITH OSCILLOSCOPES. - In general, an oscilloscope is needed to make meaningful tests with these high performance pulse generators. At least a 150-MHz scope, such as the Tektronix 454A, is desirable if meaningful measurements of test rise times and 50-MHz repetition rates are to be made. Quality of the pulse waveforms (i.e., rise time, overshoot and other aberrations) cannot be measured accurately with any scope except a sampling type. However, a rule of thumb may be used for estimating pulse quality when using a Tektronix 454A: If the pulse looks pretty good (less than 8 to 10 percent aberrations) then it will most likely meet specifications on a sample scope.

In using a scope to evaluate pulse quality, the biggest source of aberrations will be the connection between the generator and the scope. Best results will be realized if the generator BNC connector is terminated immediately in a 50-ohm load and the scope probe terminated directly in that load (via an adaptor). If a coaxial cable must be used, then it must have 50 ohms characteristic impedance and be terminated in a 50-ohm load at the scope terminals.

In general, this method will show certain aberrations on the scope because of less than perfect 50-ohm transmission line characteristics at each interface. BNC connectors are used in these instruments as a matter of convenience to the average user, not because of their high-quality transmission characteristics for pulse rise times of 3 to 5 nanoseconds. Actually, BNC connectors are marginal at 3 nanoseconds. (The GR hermophroditic connector should be used for rise times of 2 nanoseconds or less if waveform quality is of great interest to the user.)

In the use of pulse generators, it is axiomatic that the number of apparent problems in per-

formance and pulse quality is inversely proportional to the experience of the user. If problems are experienced in getting the generator to do what you expect it to do, much time and frustration can be saved by consulting a resident expert in pulse work (or the factory as a last resort). Some typical problems and insights are mentioned below:

(1) The Tektronix 454A has a 2.4-nanosecond rise time which, when combined with a true 3.5-nanosecond pulse rise time, exhibits an apparent 4.25-nanosecond rise time on the scope (21 percent error).

(2) The first 4 to 5 nanoseconds along the top (and bottom) of a pulse may exhibit some aberrations as a result of cable and interface imperfections. This thesis may be tested by adding another similar piece of cable in series with the first and observing a change in the nature and duration of the aberrations. (Note: one foot of 50-ohm coaxial cable approximates 1.5 nanosecond of propagation time.) Dramatic aberrations occur if anything other than 50-ohm cable is used.

(3) Any one of the controls, (REPETITION RATE, DELAY, WIDTH, or RISE/FALL) may be adjusted incompatibly with the others and thereby totally defeat getting an expected output from the generator. The RISE/FALL controls deserve particular attention because they also can defeat the output in any mode. Unfortunately, these phenomena are intrinsic to a versatile pulse generator.

(4) It may not be obvious to the inexperienced user that certain controls are disabled in certain operating modes. For example, the DUTY CYCLE mode disables both DELAY controls plus the WIDTH range switch. (Read the specification sheet carefully.)

(5) There is a built-in delay of approximately 4 nanoseconds between the positive and negative output pulses (positive lags negative). This occurs because there is one extra Schottky gate in the positive pulse path. An additional 32 inches of 50-ohm coaxial cable can be placed in series with the negative output to compensate for this delay, if desired.

(6) If a unit does not appear to meet some specification when in the 1-volt or 10-volt output ranges, it is probably because it is not specified in those ranges. Specifications for rise time and aberrations apply principally to the 5-volt range.

b. SELF TEST. All operating modes of the generator may be tested without the use of an external generator. The internal repetition rate oscillator (clock) is free running and provides an output to the "Clock Output" connector in all modes except GATE. To test the external TRIGGER, TRIGGER DOUBLE PULSE" and PULSE AMPLIFIER modes, connect a cable between the CLOCK OUTPUT and INPUT BNC connectors and proceed as though the internal clock were an external square wave generator. To test the GATE mode, depress the MANUAL pushbutton and adjust the trigger LEVEL control for a continuous stream of pulses.

c. INITIAL TURN-ON. - To assure that some kind of pulse is put out by the generator when first setting up an experiment, set the controls as follows:

Step 1. Set MODE to DUTY CYCLE.

Step 2. Set SLOPE switch at "-".

Step 3. Set REPETITION RATE, 1 to 50 MHz range, vernier at full CCW rotation.

Step 4. Set DELAY to 10 μsec to 1 nsec range, vernier at full CCW rotation.

Step 5. Set WIDTH, 10 nsec to 1 μsec, range, adjust vernier until green "Trigger" light is on.

Step 6. Set RISE/FALL TIME, 5 nsec to 500 nsec range, verniers at full CCW rotation (P25 only.)

Step 7. Set ATTENUATORS, 5-volt range, verniers at full CW rotation.

Step 8. Set OFFSET at OFF (both outputs).

These settings should provide an 800-kHz pulse train with at least a 5-percent duty cycle. The MODE may now be switched to NORMAL for conventional pulse generator operation.

d. COMPLEMENTARY PULSE OUTPUT. The Interstate P22 and P24 generators are designed to provide complementary pulse trains at the output via use of the OFFSET control control in combination with the POLARITY control. Either positive or negative complements may be created with amplitude up to 5 volts. Offset is disabled in the 10-volt range.

In the DUTY CYCLE mode the output channel may be switched into instant complement of itself (in any voltage range) by simply reversing the Trigger SLC PE switch or momentarily depressing the MANUAL switch.

2-3. CONTROLS AND INDICATORS

Functions of the front panel controls and indicators are described in table 2-1. The Index numbers in table 2-1 are keyed to figure 2-1.

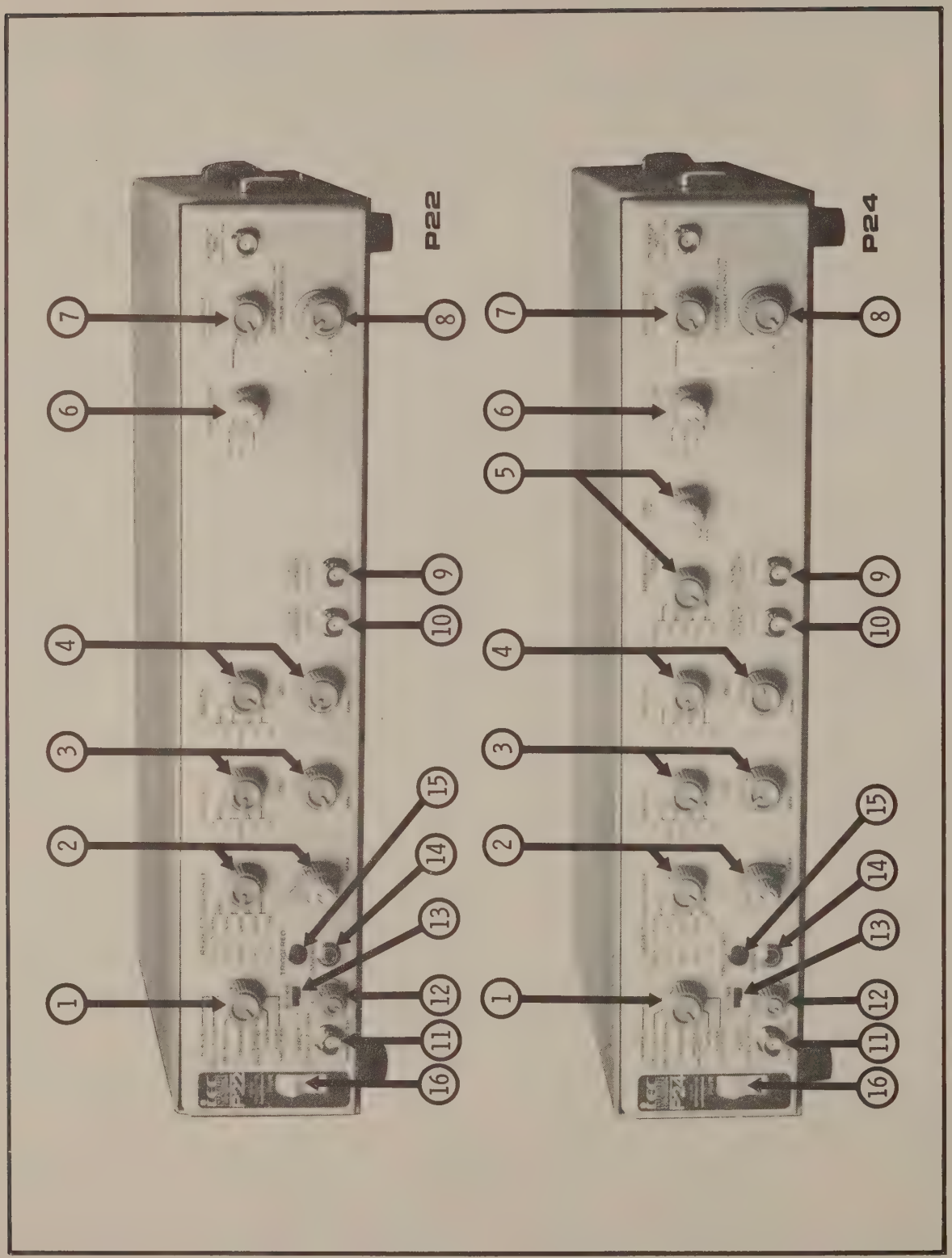


Figure 2-1. Front Panel Controls and Indicators

TABLE 2-1. FUNCTIONS OF FRONT PANEL CONTROLS AND INDICATORS

Index No.	Function	Index No.	Function
1	MODE CONTROL: A seven-position rotary switch permits the user to establish one of the following operating modes: NORMAL - Provides for a continuous train of pulses, fully controllable via REPETITION RATE, DELAY, WIDTH, etc. DUTY CYCLE - In this mode, the pulse duty cycle is caused to remain nominally constant as repetition rate varies. (Subject to the minimum pulse width limitation of 10 nsec.) The use of this mode simplifies setup in many applications because controls for DELAY range, DELAY vernier, and WIDTH range are all rendered inoperable. The WIDTH vernier is used to set the desired duty cycle. DBL PULSE: Two pulses will occur for each period of the repetition rate generator (but they will be limited to the 25-MHz rate or 50-MHz effective pulse rate). The leading pulse will be initiated nominally coincident with the positive-going SYNC output. The second pulse will be initiated at the expiration of the period established by the DELAY controls.		TRIGGER: A single-output pulse will occur in response to a voltage level change at the INPUT connector or in response to the MANUAL pushbutton. DELAY and WIDTH controls are fully operable in this and other modes unless otherwise noted. (Note: The internal clock continues to operate in all external input modes except GATE and its frequency is controlled by the REPETITION RATE controls. The clock signal is available at the CLOCK OUTPUT BNC connector.) TRIGGER DBL PULSE: Two output pulses, separated in time by the delay period, will occur in response to a voltage level change at the INPUT connector, or in response to the MANUAL pushbutton. (Internal clock runs continuously). GATE: A series of output pulses gated "on" in response to a voltage level at the INPUT connector, or in response to the MANUAL pushbutton will occur. The gating is synchronous, the first pulse starting immediately on command, and the final pulse completing a full period, even if the gating signal should go "off" during a pulse period.

Table 2-1. Functions of Front Panel Controls and Indicators (Continued)

Index No.	Function	Index No.	Function
	PULSE AMPLIFIER: A signal at the INPUT connector is squared and delivered to the output amplifier for shaping as desired. The DELAY and WIDTH controls are not functional in this mode. (Internal Clock runs continuously.)	4	WIDTH CONTROL A four-position range selector, plus a vernier with 100:1 adjustment. Combined range of adjustment is from less than 10 nsec to in excess of 1 sec with overlap between ranges. There is, however, a worst-case limitation that width may not be adjustable past 75 percent of the repetition rate period (specified to 10 MHz and decreasing to 50 percent at 50 MHz). Typically, a wider range of adjustment is attainable, up to ≈95 percent of repetition rate period. In DUTY CYCLE mode, only the WIDTH vernier is functional (width range is not used). The range of vernier adjustment in this case is 5 percent to 95 percent duty cycle, decreasing to 50 percent at 50 MHz. (Note: Trigger light will go out if vernier setting is improper.)
2	REPETITION RATE CONTROL A four-position range selector, plus a vernier with >100:1 adjustment. Combined range of adjustment is from less than 1 Hz to in excess of 50 MHz with overlap between ranges.		
3	DELAY CONTROL A four-position range selector, plus a vernier with >100:1 adjustment. Combined range of adjustment is from less than 10 nsec to in excess of 1 sec with overlap between ranges. There is, however, a worst-case limitation that delay may not be adjusted beyond 75% of the repetition rate period to 10 MHz, decreasing to 50% at 50 MHz. Typically, a wider range of adjustment is attainable up to ≈95 percent of repetition rate period. DELAY controls are functional in all modes except DUTY CYCLE and PULSE AMPLIFIER.	5	RISE/FALL CONTROL (P24 only) A four-position range selector, plus verniers with >100:1 adjustment. There are separate verniers for rise time and for fall time. The RISE/FALL TIME controls are functional in all modes of operation.

Table 2-1. Functions of Front Panel Controls and Indicators (Continued)

Index No.	Function	Index No.	Function
6	OUTPUT AMPLITUDE A three-position voltage range selector, plus a vernier. The selected range (10V, 5V, or 1V) defines the maximum obtainable voltage across a 50-ohm load. The 10V range must be terminated by a 50-ohm load. The other two ranges, because they utilize an internal 50-ohm back termination, are less demanding with regard to output load. For many applications, where a true 50-ohm environment is not essential, and where minor cable reflections are tolerable, satisfactory operation into a high impedance load is possible. Into an open circuit, the output voltage on the 5V and 1V ranges will be twice the indicated value, or 10 volts and 2 volts, but this is not true of the 10V range. Care should be exercised when using the AMPLITUDE vernier near its minimum adjustment. When amplitude is reduced below 1/5 of maximum, the nature of the bridged-T circuit of the vernier is such that pulse overshoot may be accentuated. If the user has a need for very low amplitude pulses (<200 mV) in a wideband application, it is recommended that an external attenuator be considered.	7	OUTPUT POLARITY Either positive-going or negative-going pulses may be selected by this 2-position switch and the width of the pulse remains constant. It should be noted that both offset and pulse direction change polarity when the POLARITY switch is activated. 8 OUTPUT OFFSET (and Complimentary Pulses) Offset of the pulse baseline is obtained by pulling on the CONTROL knob and then rotating it until the desired magnitude is obtained. For positive-going pulse outputs, the offset is adjustable between +1 and -6 volts. For negative-going pulse outputs, the range is -1 to +6 volts. The offset magnitude, once adjusted, is independent of the output amplitude control settings (except for the 10V range setting, where offset is completely disabled.) Either polarity may be made into the complement of the other via OFFSET. 9 SYNC OUTPUT This is a rectangular wave at TTL compatible level voltages (≈ 0

Table 2-1. Functions of Front Panel Controls and Indicators (Continued)

Index No.	Function	Index No.	Function
	to +3V into a standard TTL load). Source impedance is 50 ohms. The signal at SYNC OUTPUT is steered in accordance with the selected operating mode. In NORMAL, TRIGGER, and GATE modes, the positive-going edge of the sync waveform precedes the leading edge of each main output pulse by the adjustable delay period. For DUTY CYCLE, DBL PULSE, TRIGGER DBL PULSE, and PULSE AMPLIFIER modes, the positive-going edge of the sync waveform is nominally coincident with the leading edge of the main pulse and DELAY controls do not affect this relationship.	11	INPUT (for Trigger, Gate, or Pulse Amplifier) Accepts an external voltage level 0.7V p-p. The level may be ac, dc, or pulsed. A threshold level, at which a Schmitt Trigger generates a change of state, is adjustable between the limits of ±5 volts by means of the LEVEL control. The input impedance is 1K ohm at dc, shunted by ≈15 pF. Should the input waveform have frequency components above a few MHz, it is recommended that a source impedance of 50 ohms be employed. A word of caution is in order relative to the interaction of signals when the DUTY CYCLE mode is selected. Any signal present at the INPUT will modulate the pulse duty cycle, due to sharing of trigger circuit elements. If desired, this can provide a remote control of duty cycle.
10	CLOCK OUTPUT This is a nominal squarewave at the frequency of the repetition rate generator. The voltage levels are TTL compatible (≈ 0 to +3V into a standard TTL load). Source impedance is 50 ohms. Unlike the SYNC, the clock waveform does not have a specified time relationship to the main output pulse. The clock is available as a free-running output for all modes except GATE, where it is caused to lock up in accordance with an external level.	12	LEVEL CONTROL Adjusts the threshold level of the external input. The threshold is adjustable to occur anywhere in the region between +5 and -5 volts.

Table 2-1. Functions of Front Panel Controls and Indicators (Continued)

Index No.	Function	Index No.	Function
6	OUTPUT AMPLITUDE A three-position voltage range selector, plus a vernier. The selected range (10V, 5V, or 1V) defines the maximum obtainable voltage across a 50-ohm load. The 10V range must be terminated by a 50-ohm load. The other two ranges, because they utilize an internal 50-ohm back termination, are less demanding with regard to output load. For many applications, where a true 50-ohm environment is not essential, and where minor cable reflections are tolerable, satisfactory operation into a high impedance load is possible. Into an open circuit, the output voltage on the 5V and 1V ranges will be twice the indicated value, or 10 volts and 2 volts, but this is not true of the 10V range. Care should be exercised when using the AMPLITUDE vernier near its minimum adjustment. When amplitude is reduced below 1/5 of maximum, the nature of the bridged-T circuit of the vernier is such that pulse overshoot may be accentuated. If the user has a need for very low amplitude pulses (<200 mV) in a wideband application, it is recommended that an external attenuator be considered.	7	OUTPUT POLARITY Either positive-going or negative-going pulses may be selected by this 2-position switch and the width of the pulse remains constant. It should be noted that both offset and pulse direction change polarity when the POLARITY switch is activated. 8 OUTPUT OFFSET (and Complimentary Pulses) Offset of the pulse baseline is obtained by pulling on the CONTROL knob and then rotating it until the desired magnitude is obtained. For positive-going pulse outputs, the offset is adjustable between +1 and -6 volts. For negative-going pulse outputs, the range is -1 to +6 volts. The offset magnitude, once adjusted, is independent of the output amplitude control settings (except for the 10V range setting, where offset is completely disabled.) Either polarity may be made into the complement of the other via OFFSET. 9 SYNC OUTPUT This is a rectangular wave at TTL compatible level voltages (≈ 0

Table 2-1. Functions of Front Panel Controls and Indicators (Continued)

Index No.	Function	Index No.	Function
	to +3V into a standard TTL load). Source impedance is 50 ohms. The signal at SYNC OUTPUT is steered in accordance with the selected operating mode. In NORMAL, TRIGGER, and GATE modes, the positive-going edge of the sync waveform precedes the leading edge of each main output pulse by the adjustable delay period. For DUTY CYCLE, DBL PULSE, TRIGGER DBL PULSE, and PULSE AMPLIFIER modes, the positive-going edge of the sync waveform is nominally coincident with the leading edge of the main pulse and DELAY controls do not affect this relationship.	11	INPUT (for Trigger, Gate, or Pulse Amplifier) Accepts an external voltage level 0.7V p-p. The level may be ac, dc, or pulsed. A threshold level, at which a Schmitt Trigger generates a change of state, is adjustable between the limits of ±5 volts by means of the LEVEL control. The input impedance is 1K ohm at dc, shunted by ≈15 pF. Should the input waveform have frequency components above a few MHz, it is recommended that a source impedance of 50 ohms be employed. A word of caution is in order relative to the interaction of signals when the DUTY CYCLE mode is selected. Any signal present at the INPUT will modulate the pulse duty cycle, due to sharing of trigger circuit elements. If desired, this can provide a remote control of duty cycle.
10	CLOCK OUTPUT This is a nominal squarewave at the frequency of the repetition rate generator. The voltage levels are TTL compatible (≈ 0 to +3V into a standard TTL load). Source impedance is 50 ohms. Unlike the SYNC, the clock waveform does not have a specified time relationship to the main output pulse. The clock is available as a free-running output for all modes except GATE, where it is caused to lock up in accordance with an external level.	12	LEVEL CONTROL Adjusts the threshold level of the external input. The threshold is adjustable to occur anywhere in the region between +5 and -5 volts.

Table 2-1. Functions of Front Panel Controls and Indicators (Continued)

Index No.	Function	Index No.	Function
	Under certain conditions where fast rise/fall time pulses are utilized as an input, the LEVEL control can be adjusted for not only the usual level sensitivity, but it can also be adjusted for an effect best described as edge triggering. In other words, a type of dv/dt sensitivity can be obtained which will cause the input pulse to be effectively differentiated. Should this occur, the output of the Schmitt trigger will consist of narrow spikes whose width is unrelated to the true width of the actual input pulse. When in TRIGGER modes, the effect will be that triggering can occur on the wrong edge of the input pulse. In the GATE and PULSE AMPLIFIER modes, the effect will be one of the incorrect gate time or pulse time. In either case, simply use additional care in adjusting the LEVEL control to reject this "edge triggered" condition.		the SLOPE switch at "+"; for the converse, place the SLOPE switch at "-". When operating in the DUTY CYCLE mode, the position of the SLOPE switch determines the direction of rotation of the WIDTH vernier for increasing pulse width. For width increasing in the CW direction, the SLOPE switch should be at "-". As an adjunct to this relationship, an "instant complement" of the pulse waveform can be formed by simply reversing the position of the SLOPE switch (or, momentarily, by depressing the MANUAL pushbutton).
13	SLOPE SWITCH Determines whether a positive-going or negative-going INPUT level will cause the desired instument response. For triggering on the positive-going input, or enabling the gate or pulse amplifier on the more positive portion of the input, place	14	MANUAL PUSHBUTTON Pushing or releasing this panel control will simulate a crossing of the threshold of an external input. The sense of the control (that is, whether it activates the generator upon pushing or upon releasing) is a function of the combined settings of SLOPE and LEVEL controls. The pushbutton will activate upon release provided that the SLOPE switch and LEVEL control are both set the same polarity (i.e., SLOPE at "+" and LEVEL at "+5"). By

Table 2-1. Functions of Front Panel Controls and Indicators (Continued)

Index No.	Function	Index No.	Function
	reversing either SLOPE or LEVEL, but not both, activiation will occur upon pushing.		Four distinct levels of a-c input voltage may be employed to power SERIES 20 instruments. A selector switch, at the rear panel, allows a first-level selection of either 115V or 230V nominal value. A second-level selection labeled FINE ADJ should be placed at normal if line voltage is within ±10 percent of nominal. A low-line position permits operation at 100 or 200V ±10 percent.
15	TRIGGERED INDICATOR Glows whenever internal or external levels are of sufficient amplitude to operate the generator circuits. A nominal 1-second time constant in the lamp circuit prevents blinking, except for operation at extremely low repetition rates.		**CAUTION** Be sure to check the rating of the installed fuse before placing the instrument into service or after changing voltage settings: 100/115V - 3/4A Slo-Blo 200/230V - 3/8A Slo-Blo
16	AC POWER SWITCH & INDICATOR- Switch glows when power is turned on.		
17	AC POWER SELECTION (Rear Panel)		

Section 3
CIRCUIT DESCRIPTION

3-1. INTRODUCTION

The simplified block diagram, figure 3-1, shows the major functional blocks and signal flow of the P22 and P24 pulse generators. A greater level of detail is shown in section 5 in the block diagrams for each mode and in the overall schematic diagram in section 7.

Each basic circuit group in the detailed diagrams and schematics (sections 5 and 7) has been labeled according to function; i. e., CLOCK, POSITIVE OUTPUT, AMPLIFIER, etc. Further, each group has been given a three-digit number unique to that function; i. e., CLOCK (100-199), POSITIVE OUTPUT AMPLIFIER (500-599), etc. Thus, Q101 is the transistor Q1 in the clock circuit. Zones on the printed circuit board are labeled with both name and number; i. e., CLOCK 1XX, and individual components are labeled with the last two digits only.

3-2. POWER SUPPLY (Ref. 9XX)

a. UNREGULATED DC AND RECTIFIERS. - Three unregulated d-c voltages, nominally +28, -28, and +10 volts, are generated to supply voltage regulator circuits. In turn, constant d-c voltages are utilized by all instrument circuits. Two center-tapped secondary transformer windings and three sets of full-wave rectifiers, plus filter capacitors, are used.

b. REGULATED SUPPLIES. - There are three regulated d-c supplies: +20, -20, and +5 volts. The +20-volt supply, adjustable by R909, is used as a reference for the complementary, tracking -20-volt supply. IC901 and IC902 are high-gain regulating amplifiers. Q903 and Q906 provide overcurrent protection in the event of an overload or short circuit.

The +5-volt regulated supply is nonadjustable, and is independent of the +20 and -20-volt supplies. It utilizes a single-package integrated circuit, IC903. Self-protecting thermal shutdown is inherent in the circuit.

The actual currents drawn from the various supplies are dependent upon load and control settings, but nominal maximums are 1 ampere for each of the 20-volt supplies, and one-half ampere for the +5-volt supply.

3-3. CLOCK (Ref. 1XX)

The clock, or repetition rate generator, produces a triangular shaped waveform. Controllable currents, caused to alternately charge and discharge a selectable timing capacitor, determine the clock frequency.

a. CURRENT CONTROL. - The front panel REP RATE VERNIER control, R2, controls the amount of collector current flowing at Q101.

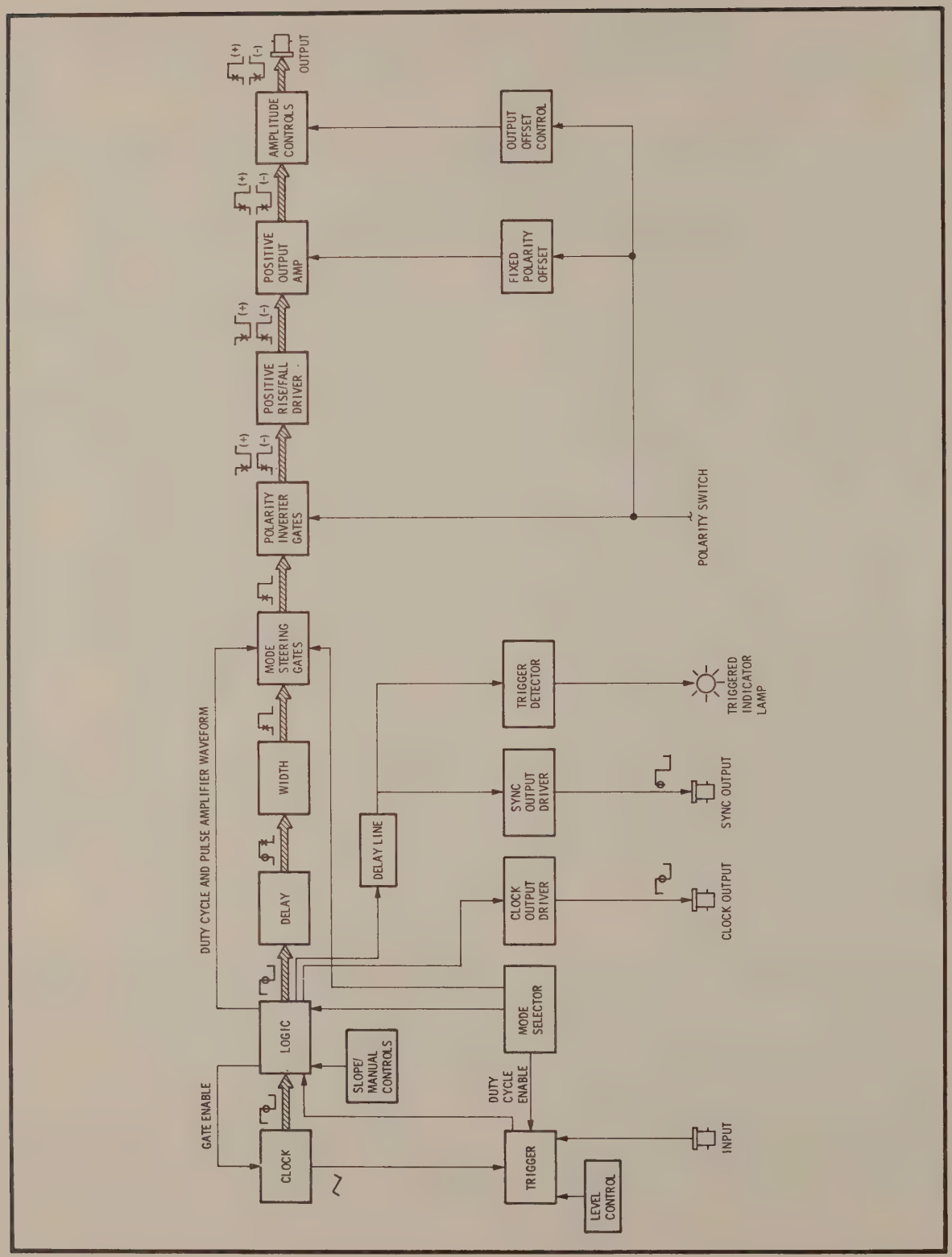


Figure 3-1. Simplified Block Diagram-P22 and P24 Pulse Generators

A tracking amplifier, IC101, causes a 2x current flow at Q104 collector. Current switches Q102 and Q103, controlled in accordance with the triggering action of tunnel diodes TD101 and TD102, direct the net flow of current into timing capacitor mode TP101, causing alternate charging and discharging of the selected timing capacitance.

b. TRIANGULAR WAVEFORM. - The triangular waveform, at Q110 emitter, is directly utilized (in the DUTY CYCLE mode only) at the trigger circuits (ref. 4XX); otherwise, it is merely an internal timing waveform not directly used elsewhere within the instrument.

c. SQUARE (DIGITAL) WAVEFORM. - There is a pulsed waveform developed at tunnel diodes TD101 and TD102, which principally controls the triangular waveform, and, in addition, also sets and resets current mode latch Q107, Q108, and Q112. The output (collector) of Q108, which has a signal level of 2 volts p-p, is buffered by emitter follower Q109. A 50-ohm transmission line couples the squarewave signal to the logic circuits (Ref. 8XX).

3-4. TRIGGER (Ref. 4XX)

An external trigger signal, applied to INPUT connetor J2, is summed at TP 401 with a controllable d-c current caused to flow through Q401. Current mode Schmitt Trigger Q405, Q404, and Q407, delivers a pulse waveform whenever the external signal plus the summed d-c control current reverse polarity. When operating in the DUTY CYCLE mode, a similar action is caused to occur once per clock cycle. The level at which the pulsed waveform is caused to change state determines the duty cycle of the pulse.

3-5. LOGIC (Ref. 8XX)

The Logic section accepts inputs from either the clock (to Q801) or from the trigger section (to Q806). These inputs are first converted to standard TTL levels, and are then steered in accordance with the selected operating mode of the instrument. Outputs from the Logic section are routed to the following:

- Delay section (all modes except DUTY CYCLE and PULSE AMPLIFIER)
- Clock section (to turn on the Clock in the GATE mode)
- Rise/Fall section (DUTY CYCLE and PULSE AMPLIFIER modes)
- Clock Output and Sync Output driver circuits.

A fixed-time delay circuit, IC805 and IC806, is inserted to provide the proper calibrated time delay of the SYNC OUTPUT relative to the main OUTPUT.

3-6 DELAY (Ref. 2XX)

The DELAY generator is a one-shot circuit, triggered from the Logic Section. A controllable current, via Q201, charges a selectable timing capacitance at node TP201. When the timing capacitance charges to a nominal 2.2-volt level, the circuit is caused to reset to its quiescent level, awaiting a subsequent retrigger.

3-7. WIDTH (Ref. 3XX)

The WIDTH circuit description is identical to that of the DELAY (paragraph 3.6) except that the trigger source for WIDTH is the

DELAY generator, whose signal pulse is processed via IC302. The output of IC302 (pin 6) is a single differentiated pulse, or, in the DBL PULSE mode, two pulses per clock cycle.

3-8. RISE/FALL (VARIABLE) (Model P24, Ref. 5XX)

The RISE/FALL section accepts a TTL-level pulse input. The TTL pulse is level-shifted, then shaped as necessary to develop the required pulse waveform for amplification at the output amplifier.

Independently controllable currents, via Q501 and Q508, are caused to charge and discharge a selectable timing capacitance. The resultant charge/discharge rates determine the rise and fall times of the final pulse.

Pulse amplitude is established by clamp transistors Q504, Q505, Q510, and Q512. Emitter follower amplifiers Q513 and Q514 provide a low-impedance drive source to the final output amplifier.

3-9. POLARITY INVERTER GATES (Ref. 5XX)

TTL gates are used to invert the pulse train when the NEGATIVE POLARITY is commanded. These gates are controlled directly by the POLARITY switch on the front panel.

3-10. RISE/FALL DRIVER (Model P22, Ref. 5XX)

The fixed Rise/Fall Driver, used in Model P22, is a much simplified version of the variable circuits described in paragraph 3-7. The TTL input is level shifted, then caused to switch bipolar currents, of constant amplitude, directly to the final output amplifier.

3-11. OUTPUT AMPLIFIER (Ref. 5XX)

The Output Ampifier accepts a bipolar, pulse waveform from its associated Rise/Fall circuit. The pulse waveform is level shifted via common base amplifier Q552, then is converted to a nominal 0 to 200 mA high-level current pulse by Q559 and Q560. The resultant current is power amplified, which involves coupling via common-base amplifiers Q561 and Q562 to the output attenuator and load circuit.

3-12. FIXED POLARITY OFFSET (Ref. 7XX)

This offset circuit is a fixed current source which is connected directly to the output of the OUTPUT AMPLIFIER ahead of the attenuator and level controls. When NEGATIVE polarity is commanded, the pulse train is inverted by the POLARITY INVERTER GATES and offset in the negative direction by the FIXED POLARITY OFFSET circuit. The combination of these two circuits produces the desired negative pulse train at the OUTPUT.

3-13. OFFSET (Ref. 7XX)

Offset is generated by an adjustable d-c current which flows into the output circuit impedance and through its ground return. The resultant voltage offset at the instrument terminals is the product of this adjustable current and the net output circuit resistance. Inductors L701 through L705, together with associated damping resistors, serve to isolate the 50-ohm matched output impedance from the undesirable impedance characteristics of current source transistors Q705 and Q706.

3-14. ATTENUATOR ASSEMBLY (Ref. 0XX)

Output amplitude control is obtained by a combination of three methods:

- A 50-ohm continuously variable constant impedance bridged-T attenuator.

- A fixed, switchable, 14-dB attenuator (used on the 1V range).

- Switch disconnect of the 50-ohm internal "back termination" at the output amplifier. This provides up to 10 volts across an external 50-ohm load, although at the expense of waveform quality, rise/fall times, and loss of offset capabilities. These disadvantages are practical limitations on power and voltage of the output amplifier, plus unavoidable impedance discontinuities at the amplifier output terminals.

NOTES

Section 4
CALIBRATION AND PERFORMANCE TESTS

4-1. INTRODUCTION

This section contains the list of necessary equipment and the detailed procedures for checking your SERIES 20 pulse generator for proper operation and/or calibration of all elements of the instrument.

4-2. SUGGESTED RECEIVING INSPECTION TESTS

Just prior to shipment, the generator was processed through an automated test facility to verify calibration and operation. The following procedure is recommended for customers who have not developed their own formal acceptance test procedure.

a. EQUIPMENT REQUIRED.

- Oscilloscope (150 MHz desired, 50 MHz or greater required)
- 50-ohm termination (may be built into scope)
- 50-ohm BNC cables, 2 each

b. PROCEDURE.

Step 1. Upon unpacking the generator, check the position of rear panel power selector switches and fuse size if other than 115-volt line power is to be used. When shipped, the power selector switches were set for normal 115-volt operation and a 3/4-amp fuse was installed for 115-volt use.

NOTE

Refer to Section 2 of this manual for location of all controls.

Step 2. Apply power and note illumination of lamp in power switch.

Step 3. Attach (scope) to OUTPUT connector using 50-ohm termination at the face of the instrument under test. Attach SYNC OUTPUT to scope TRIG INPUT connector.

Step 4. Set generator controls as follows:

MODE SWITCH:	Normal
REP RATE:	10K to 1-MHz; vernier: full CW
DELAY:	10-nsec to 1-μsec; vernier: full CCW
WIDTH:	10-nsec to 1-μsec; vernier: full CCW
RISE/FALL:	5-nsec to 500-nsec; vernier(s): full CCW (P24 only)
AMPLITUDE:	5V vernier: full CW
OFFSET SW:	Off (pushed in)
OUTPUT POLARITY:	(+)

Step 5. Observe presence of a positive-going pulse train on scope and also observe that "triggered" lamp is on. Refer to paragraph 2-2 of this manual for comments on observed waveform quality and rise time.

Step 6. Vary, one by one, verniers for REP RATE, DELAY, WIDTH, and AMPLITUDE and observe appropriate response on scope display.

Step 7. Pull OFFSET switch ON, rotate vernier and observe vertical displacement of waveform on scope display. Push OFFSET OFF.

Step 8. Switch OUTPUT POLARITY to (-) and observe negative going pulse train.

Step 9. Reset all controls as in Step 4.

Step 10. Turn MODE switch to DUTY CYCLE. Rotate WIDTH vernier to achieve variable waveform duty cycle. (Note: TRIGGER light is on whenever waveforms are present.) Set DUTY CYCLE at approximately 50 percent.

Step 11. Rotate RISE and FALL verniers and observe change in rise and fall times of pulses (P24 only).

Step 12. Turn AMPLITUDE switch to 10V and 1V positions. Observe appropriate amplitude change on scope.

Step 13. Turn MODE switch to DBL PULSE; rotate DELAY vernier to achieve double pulse display.

Step 14. Turn MODE switch to TRIGGER. Attach a cable between CLOCK OUTPUT and trigger INPUT connectors. (This allows the generator clock to act as a source of external trigger signals and confirms that the CLOCK OUTPUT is operating properly. Rotate trigger LEVEL control until pulses appear on scope display.

Step 15. Turn MODE switch to TRIGGER DBL PULSE, and rotate DELAY vernier to obtain double pulses on scope display.

Step 16. Remove cable connecting CLOCK OUTPUT and Trigger INPUT. Turn MODE switch to GATE. Triggered lamp should be off at one end of Trigger LEVEL vernier and on at the other. A pulse train should be present when lamp is on.

Step 17. To complete the tests, turn MODE switch to PULSE AMPLIFIER. Observe change of d-c levels on scope whenever MANUAL pushbutton is operated or SLOPE slide switch is reversed.

4-3. CALIBRATION TEST PROCEDURES

a. TEST EQUIPMENT LIST. - The test equipment listed in table 4-1 is required to complete the calibration test procedure. The suggested model or equivalent should be used. Figure 4-1 details the adjustment and test point locations.

b. PROCEDURE. - Table 4-2 provides the recommended sequence and methods for performing the pulse generator calibration test.

NOTE

The generator control settings described in Step 4 of paragraph 4-2 are considered standard (std) for the procedure in table 4-2. The adjustment and test point locations are shown in figure 4-1.

TABLE 4-1. REQUIRED TEST EQUIPMENT

Test Equipment	Suggested Model
Digital Voltmeter 3-1/2 digits with 200% overrange	John Fluke 8110A
Counter 50 MHz, Universal Timer	HP 5326A or 5327A
Oscilloscope 150 MHz min	HP 1710A or Tektronix 454A (Caution--The 454A exhibits apparent baseline shift with duty cycle variation because of differential heating effects in the vertical amplifier.) This effect may be minimized or eliminated by a qualified scope technician at the expense of certain other deflection characteristics.
Sampling Oscilloscope 1-GHz Bandwidth	Tektronix 561B with S-3A Sampling Head
50-Ohm Terminator	Tektronix 011-0049-01
Function Generator	Interstate Electronics F31

TABLE 4-2. CALIBRATION TEST PROCEDURE

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
1.0	POWER SUPPLY	Std.	DVM-(DC)	1. Connect DVM to TP901. 2. Adjust R909 for +20.00 ±0.05V. 3. Measure: -20.0 ±0.1V at TP902 +5.0 ±0.25V at TP903	None
2.0	CLOCK				
2.1	Triangle Amplitude	Std.	Scope (D-C)	1. Connect scope to TP101. 2. Adjust R120 and R122 alternately for 1.50 ±0.05V p-p and 4.50 ±0.10V peak.	

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
2.2	Low Frequency Adjust	Std.	Scope (D-C)	1. Connect scope to TP102. 2. Connect counter to CLOCK OUTPUT. 3. Adjust R143 ≈ mid-range. 4. Adjust REPETITION RATE vernier for ≈ 100 kHz. 5. Adjust R103 for highest frequency 6. Adjust REPETITION RATE vernier to MIN (CCW). 7. Adjust R158 for positive going 1/2 cycle duration of 62 ±3 μsec at TP102. 8. Adjust R103 for 8.0 ±0.5 kHz	10 kHz MAX
2.3	High Frequency Adjust	Std.	Counter Frequency	1. Connect counter to CLOCK OUTPUT. 2. Adjust REPETITION RATE vernier to MAX (CW). 3. Adjust R143 for 1.15 ±0.10 MHz.	1.0 MHz MIN
2.4	Frequency Calibration 10- kHz - 100 Hz	Std. except REPETITION RATE range 10 kHz to 100 Hz	Counter Frequency	1. Connect Counter to CLOCK OUTPUT. 2. Measures frequency of 10.5 kHz MIN. 3. Adjust R143 for 11.0 ±0.5 kHz only if necessary. 4. Adjust REPETITION RATE vernier to MIN (CCW). 5. Measure frequency 90-Hz MAX. 6. Adjust R103 for 85 ±5 Hz only if necessary.	10 kHz MIN 100 Hz MAX

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
2.5	Frequency Calibration 100 Hz to 1 Hz	Std. except REPETITION RATE range 100 Hz to 1 Hz	Counter (period)	1. Connect counter to CLOCK OUTPUT. 2. Measure period of 1.11 sec MIN. 3. Adjust R152 for 1.18 ±0.07 sec only if necessary. 4. Adjust REPETITION RATE vernier to MAX (CW). 5. Measure frequency of 105 Hz MIN. 6. Adjust R143 for 110 ±5 Hz only if necessary.	1.00 sec MIN 100 Hz MIN
2.6	Frequency Calibration 50 MHz to 1 MHz	St. except REPETITION RATE range 50 MHz to 1 MHz	Counter (Frequency)	1. Connect counter to CLOCK OUTPUT. 2. Adjust R151 for frequency of 51.5 ±0.5 MHz. 3. Adjust REPETITION RATE vernier to MIN. 4. Measure frequency of 900 kHz MAX.	50 MHz
2.7	Frequency Jitter Check	Std. except REPETITION RATE range 10 kHz to 100 Hz	Scope (DC)	1. Adjust REPETITION RATE vernier to MAX. 2. Connect scope input to CLOCK OUTPUT. 3. Set scope sweep for 'A' intensified by 'B' with 'A' sweep set at 0.1 msec/division and 'B' sweep for 0.1 μsec/division. 4. Adjust REPETITION RATE vernier until the waveform transition points coincide with scope graticule (≈ 10 kHz). 5. Set scope on (+) slope, internal sync, and adjust intensified spot until it is located on the second cycle leading edge.	

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
2.7 (Cont)				6. Switch scope to delayed sweep. Second cycle transition jitter must be less than one major division p-p.	0.1% MAX
3.0	DUTY CYCLE				
3.1	Range Adjust	Std. except Mode: DUTY CYCLE REPETITION RATE range 10 kHz to 100 Hz	Scope (AC) Counter Frequency	1. Connect counter to pulse gen INPUT BNC. 2. Connect counter to CLOCK OUTPUT. 3. Adjust REPETITION RATE vernier for ≈5 kHz. 4. Adjust R411 so that the observed waveform is approximately the same p-p amplitude at each end of the WIDTH vernier control range.	Note: In this mode WIDTH vernier functions over first 120° of control rotation (approximately).
4.0	GATE				
4.1	First Cycle Adjust	Std. except Mode: GATE REPETITION RATE range 10 kHz to 100 Hz	Scope (DC)	1. Connect scope to TP102. 2. Connect an external signal source of ≈1.5V at 500 Hz to the INPUT BNC. 3. Sync scope on the external generator. 4. Adjust TRIGGER LEVEL control for a 1-msec burst of triangle waves at TP102. 5. Adjust R126 so that the negative peak at the start of the burst is level with succeeding negative peaks.	

Table 4-2. Calibration Test Procedure (Continued)

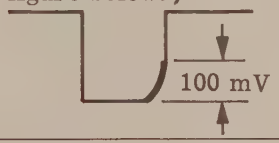
Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
5.0	DELAY				
5.1	Trigger Point Adjust	Std. except Mode: NORMAL REPETITION RATE range 10 kHz to 100 Hz. DELAY: 100 μsec to 10 msec	Scope (AC) Counter (Frequency)	1. Connect counter to CLOCK OUTPUT. 2. Connect scope probe to TP203. 3. Adjust REPETITION RATE vernier for ≈2 kHz. 4. Adjust C211 for maximum capacity. 5. Adjust R221 such that a 0.7V pulse, 100 μsec wide, is observed. 6. Optimize R221 by adjusting for a trigger point of 100 mV. (See figure below.) 	METAL TAB MAX. CAPACITY SETTING
5.2	Delay Jitter Test	Same as 5.1	Scope (DC) Counter (Frequency)	1. Connect counter to CLOCK OUTPUT. 2. Connect scope probe to TP202. 3. Adjust REPETITION RATE for ≈2 kHz. 4. Set scope on internal (+) sync. Set sweep for 'A' intensified by 'B' with 'A' sweep set at 0.1 msec/division and 'B' sweep for 0.1 μsec/division. 5. Adjust DELAY vernier for 100 μsec wide pulse. 6. Adjust intensified spot until it is located on the trailing edge of the first pulse. 7. Switch scope to delayed sweep. The trailing edge transition jitter must be less than one major division p-p. 8. Return scope sweep to normal.	0.1% MAX

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
5.3	Delay calibration 100 μsec to 10 msec Range	Same as 5.1	Scope (DC) Counter (Frequency)	1. Connect scope probe to TP202. 2. Connect counter to CLOCK OUTPUT. 3. Adjust REPETITION RATE vernier for ≈ 2 kHz. 4. Adjust DELAY vernier to MIN. 5. Adjust R201 for a pulse width of 85 ±5 μsec. 6. Select REPETITION RATE range of 100 Hz to 1 Hz. 7. Adjust REPETITION RATE vernier for ≈ 50 Hz. 8. Adjust DELAY vernier to MAX. 9. Adjust R208 for pulse width of 12.5 ±0.5 msec.	100 μsec MAX 10 msec MIN
5.4	Delay Calibration 10 msec to 1 sec Range	Std. except Mode: TRIGGERED	Scope (DC)	1. Connect scope probe to TP202. 2. Press MANUAL trigger to observe pulse at TP202. 3. Measure pulse widths <1.11 sec. 4. Adjust R208 for 1.18 ±0.07 sec only if required. 5. Select NORMAL mode. 6. Adjust DELAY vernier to MIN. 7. Measure pulse width >9.5 msec. 8. Adjust R201 for 9.0 ±0.5 msec only if required.	1.00 sec 10 msec MAX

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
5.5	Delay Calibration 1 μsec to 100 μsec Range	Std. except DELAY 1 μsec to 100 μsec	Scope (DC) Counter (Frequency)	1. Connect scope probe to TP202. 2. Connect counter to CLOCK OUTPUT. 3. Adjust REPETITION RATE vernier for ≈500 kHz. 4. Adjust DELAY vernier to MIN. 5. Measure pulse width <0.95 μsec. 6. Adjust R201 for 0.90 ±0.5 μsec only if required. 7. Select REPETITION RATE range of 10 kHz to 100 Hz. 8. Adjust DELAY vernier to MAX. 9. Measure pulse width >111 μsec. 10. Adjust R208 for 118 ±7 μsec only if required.	1.00 μsec MAX 100 μsec MIN
5.6	Delay Calibration 10 nsec to 1 μsec Range	Std.	Scope (DC) Counter (Frequency)	1. Connect scope to TP202. 2. Connect counter to CLOCK OUTPUT. 3. Adjust REPETITION RATE vernier for ≈500 kHz. 4. Adjust DELAY vernier to MAX. 5. Measure 1.5 μsec > pulse width >1.1 μsec. 6. Adjust C202 for 1.2 ±0.1 μsec only if required.	1.0 μsec MIN
5.7	Delay Differential Calibration	Std. except Mode: GATE REPETITION RATE range 1 MHz to 50 MHz	Scope (DC)	1. Connect scope to TP202. 2. Connect external signal source of ≈1.5V p-p at 3 MHz to the trigger INPUT (sine or square-wave). 3. Sync scope on external generator.	

Table 4-2. Calibration Test Procedure (Continued)

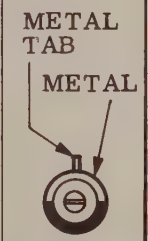
Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
5.7 (Cont)				4. Adjust Level control until TRIGGERED lamp illuminates. 5. Adjust C211 to ensure that there are no missing pulses in the pulse burst. 6. Vary the REPETITION RATE vernier slightly, checking for pulse drop out.	
6.0	WIDTH				
6.1	Trigger Point Adjust	Std. except REPETITION RATE range 10 kHz to 100 Hz. WIDTH range 100 μsec to 10 msec	Scope (AC) Counter (Frequency)	1. Connect scope probe to TP303. 2. Connect counter to CLOCK OUTPUT. 3. Adjust REPETITION RATE vernier for ≈ 2 kHz. 4. Adjust C309 to maximum capacity. 5. Adjust R326 so that a 0.7V pulse ≈100 μsec wide wi observed. 6. Optimize R326 by adjusting for trigger point of 100 mV. (See figure below.) 	
6.2	Width Jitter Test	Same as 6.1	Scope (DC) Counter (Frequency)	1. Connect scope probe to TP302. 2. Connect counter to CLOCK OUTPUT. 3. Adjust REPETITION RATE vernier for ≈ 2 kHz. 4. Adjust WIDTH vernier for 100-μsec wide pulse.	

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
6.2 (Cont)				5. Set scope on internal (+) sync. Set sweep for 'A' intensified by 'B' with 'A' sweep set at 0.1 msec/division and 'B' sweep for 0.1 μsec/division. 6. Adjust intensified spot until it is located on the trailing edge of the first pulse. 7. Switch scope to delayed sweep. Trailing edge transition jitter must be less than one major division p-p. 8. Return scope sweep to normal.	0.1% MAX
6.3	Width Calibration 100 μsec to 10	Same as 6.1	Scope (DC) Counter (Frequency)	1. Connect scope to TP302. 2. Connect counter to CLOCK OUTPUT. 3. Adjust WIDTH vernier to MIN. 4. Adjust R301 for pulse width of 85 ±5 μsec. 5. Select REPETITION RATE range of 100 Hz to 1 Hz. 6. Adjust REPETITION RATE vernier for ≈ 50 Hz. 7. Adjust WIDTH vernier to MAX. 8. Adjust R308 for pulse width of 12.5 ±0.5 msec.	100 μsec MAX 10 Msec MIN
6.4	Width Calibration 10 msec to 1 sec Range	Std. except Mode: TRIGGER WIDTH 10 msec to 1 sec	Scope	1. Connect scope to TP302. 2. Press MANUAL trigger to observe a pulse width >1.11 sec. 3. Adjust R308 for 1.18 ±0.07 sec only if required. 4. Select NORMAL mode. 5. Adjust WIDTH vernier to MIN.	1.00 sec MIN

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
6.4 (Cont)				6. Measure pulse width <9.5 msec. 7. Adjust R301 for 9.0 ±0.05 msec only if required.	9.0 msec MAX
6.5	Width Calibration 1 μsec to 100 μsec Range	Std. except WIDTH 1 μsec to 100 μsec	Scope (DC) Counter	1. Connect scope to TP302 2. Connect counter to CLOCK OUTPUT. 3. Adjust REPETITION RATE vernier for ≈ 500 kHz. 4. Measure pulse width < 0.95 μsec. 5. Adjust R301 for 0.90 ±0.5 μsec only if required. 6. Select REPETITION RATE range of 10 kHz to 100 kHz. 7. Adjust WIDTH vernier to MAX. 8. Measure pulse width >111 μsec. 9. Adjust R308 for 118 ±7 μsec only if required.	1.00 μsec MAX 100 μsec
6.6	Width Calibration 10 nsec to 1 μsec Range	Std. except WIDTH vernier at MAX	Scope (DC) Counter (Frequency)	1. Connect scope probe to TP302. 2. Connect counter to CLOCK OUTPUT. 3. Adjust REPETITION RATE vernier for ≈ 500 kHz. 4. Measure 1.5 μsec > pulse width >1.1 μsec. 5. Adjust C302 for 1.2 ±0.1 μsec only if required. NOTE WIDTH calibration is not complete until Step 10 is also completed.	

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
7.0	RISE-FALL (Model P24 only)				
7.1	Clamp Adjust and factory select Components	Std. except REPETITION RATE range 10 kHz to 100 Hz WIDTH 100 μsec to 1 μsec RISE/FALL 500 nsec to 50 μsec	Scope (DC)	1. Connect scope to TP504. 2. Adjust WIDTH vernier for ≈2 μsec-wide pulse as shown below: 3. Adjust R521 and R524 so that peak levels e_1 and e_2 are at the maximum permitted by the controls. 4. Reconnect scope to TP501. 5. Adjust R530 for a positive peak level of +1.75 ±0.05V. 6. Adjust R535 for a negative peak level of -1.75 ±0.05V. 7. Select REPETITION RATE range of 1 MHz to 10 kHz. 8. Select RISE/FALL time of 5 nsec to 500 nsec. 9. Select WIDTH range of 10 nsec to 1 μsec. 10. Adjust RISE/FALL verniers to MIN. 11. Adjust WIDTH vernier for nominal square-wave. 12. Reconnect scope to TP502.	

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
				13. Verify that the waveform exhibits minimal overshoot and minimal tilt. (Note: This is a low-level, ≈100 mV p-p, a-c coupled waveform. Ignore any component of high frequency and ringing.) If required, install new select capacitor C524. 14. Reconnect scope to TP503. 15. Verify that the waveform exhibits minimal overshoot and minimal tilt. (Note: This is a low-level, ≈100 mV p-p, a-c coupled waveform. Ignore any component of high frequency and ringing.) If required, install new select capacitor C527.	
7.2	Start Up Adjust	Std. except WIDTH 1 μsec to 100 μsec	Scope (DC)	1. Connect scope to TP501 2. Adjust FALL time vernier fully CW. 3. Adjust WIDTH and REPETITION RATE vernier for waveform with flat top and bottom. 4. Adjust R524 such that the start (≈5% amplitude) up to the slow ramp is delayed by ≈100 nsec as compared to the start up when the FALL TIME vernier is fully CCW. (Note: the 100 nsec criterion is only a guide. The main objective is to obtain a problem-free waveform with a small delay.)	

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
7.2 (Cont)				5. Adjust the RISE TIME vernier fully CW, and the FALL TIME vernier fully CCW. 6. Adjust WIDTH vernier for waveform with flat top and bottom. 7. Adjust R521 so that startup of the slow ramp is delayed by ≈100 nsec as compared to startup when the RISE TIME vernier is fully CCW. Note: The 100 nsec criterion is only a guide. The main objective is to obtain a problem-free waveform with a small delay.	
7.3	RISE/ FALL Calibration 5 nsec to 500 nsec Range	Std. except REPETITION RATE range 10 kHz to 100 Hz	Scope (DC)	1. Connect scope to TP501. 2. Adjust RISE/FALL verniers to MAX. 3. Adjust REPETITION RATE and WIDTH verniers so that the rise and fall of the waveform is terminated by a flat top and bottom. 4. Measure the 10% to 90% transition times of rise and fall. Verify the shorter of the two intervals as 540 ±20 nsec. If required, select capacitor (C501).	
8.0	OUTPUT AMPLIFIER ADJUST				
8.1	Baseline Adjust	Std. except Mode: TRIGGER (Do not apply an external signal)	DVM- (DC)	1. Connect DVM to output BNC connector via a 50-ohm ±2% feedthrough terminator. 2. Adjust R566 for a d-c output of +2 mV.	

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
8.2	Amplitude Adjust	Std. except Mode: PULSE AMPLIFIER	DVM (DC)	1. Connect DVM to output BNC connector via 50-ohm ±2% feedthrough terminator. 2. Set SLOPE switch to (+). 3. Adjust LEVEL to MAX CW (+5). 4. Verify AMPLITUDE in 5V position and vernier at MAX CW. 5. Measure d-c voltage of 5.2 ±0.1V. 6. If required, adjust voltage by selecting emitter resistors R572 and R575. The values should not differ by more than ≈10%. The smaller the value, the larger the output voltage.	5.12 ±0.1V
8.3	Abberration Adjust	Std. except Mode: DUTY CYCLE	Scope (DC) Sampling Oscilloscope (DC)	1. Connect scope to positive (negative*) output BNC connector. 2. Adjust WIDTH vernier while observing the p-p amplitude and baseline shift with duty cycle. 3. Verify that p-p amplitude variations are <5%. If required, select resistor R559 which minimizes aplitude variations with duty cycle. Changes in R559 may change output amplitude in which case step 8.2 must be repeated. 4. Disconnect the scope from the output. 5. Connect sampling oscilloscope to output BNC. 6. Adjust WIDTH vernier for ≈200 nsec wide pulse. 7. Using the scope, observe the leading edge of the output pulse.	

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
8.3 (Cont)				8. For P24 only, verify that the output pulse exhibits <5% overshoot, ringing and other aberrations while maintaining a rise time <5 nsec. If required, select resistors and capacitors R554, C578, C554 and C557 with one-half or full bead. 9. For P22 only, verify that the output pulse exhibits <5% overshoot ringing and other aberrations while maintaining a rise time <3.5 nsec. If required, select resistors and capacitors R585, R586, C578, and R557 with one-half bead or full bead.	
9.0	OFFSET				
9.1	Offset Calibration	Std. except Mode: TRIGGER	DVM (DC)	1. Connect DVM to OUTPUT with 50-ohm ±2% feedthrough load resistor. 2. Pull OFFSET to the ON position and adjust fully CW. 3. Adjust R715 for +1.10 ±0.05 dc on the DVM. 4. Adjust OFFSET to the fully CCW position. 5. Adjust R714 for -6.2 ±0.1V d-c on the DVM. 6. Switch OFFSET to the OFF position.	
10.0	DBL PULSE				
10.1	Pulse Width Adjust	Std. except Mode: DBL PULSE REPETITION RATE 50 MHz to 1 MHz	Counter (Frequency) Scope (DC)	1. Connect counter to CLOCK OUTPUT. 2. Connect scope to OUTPUT with 50-ohm ±2% feedthrough termination resistor.	

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
10.1 (Cont)				3. Adjust REPETITION RATE vernier for ≈7 MHz on counter. 4. Adjust DELAY vernier for 40 nsec between pulses. 5. Adjust C315 to largest capacity which sets the first pulse to a width of 10 nsec. Adjust C309 so that the second pulse has approximately the same width as the first and 10 nsec.	
11.0	POLARITY OFFSET				
11.1	Polarity Offset Calibration	Std. except Mode: TRIGGER POLARITY: (-)	DVM (DC)	1. Connect DVM to OUTPUT with 50 ohm ±2% feedthrough load resistor. NOTE The unit should be allowed to warm up for at least 30 minutes in the case before making next adjustment. 2. Adjust R66 for 0.0 ±0.005 volts d.c. on the DVM.	

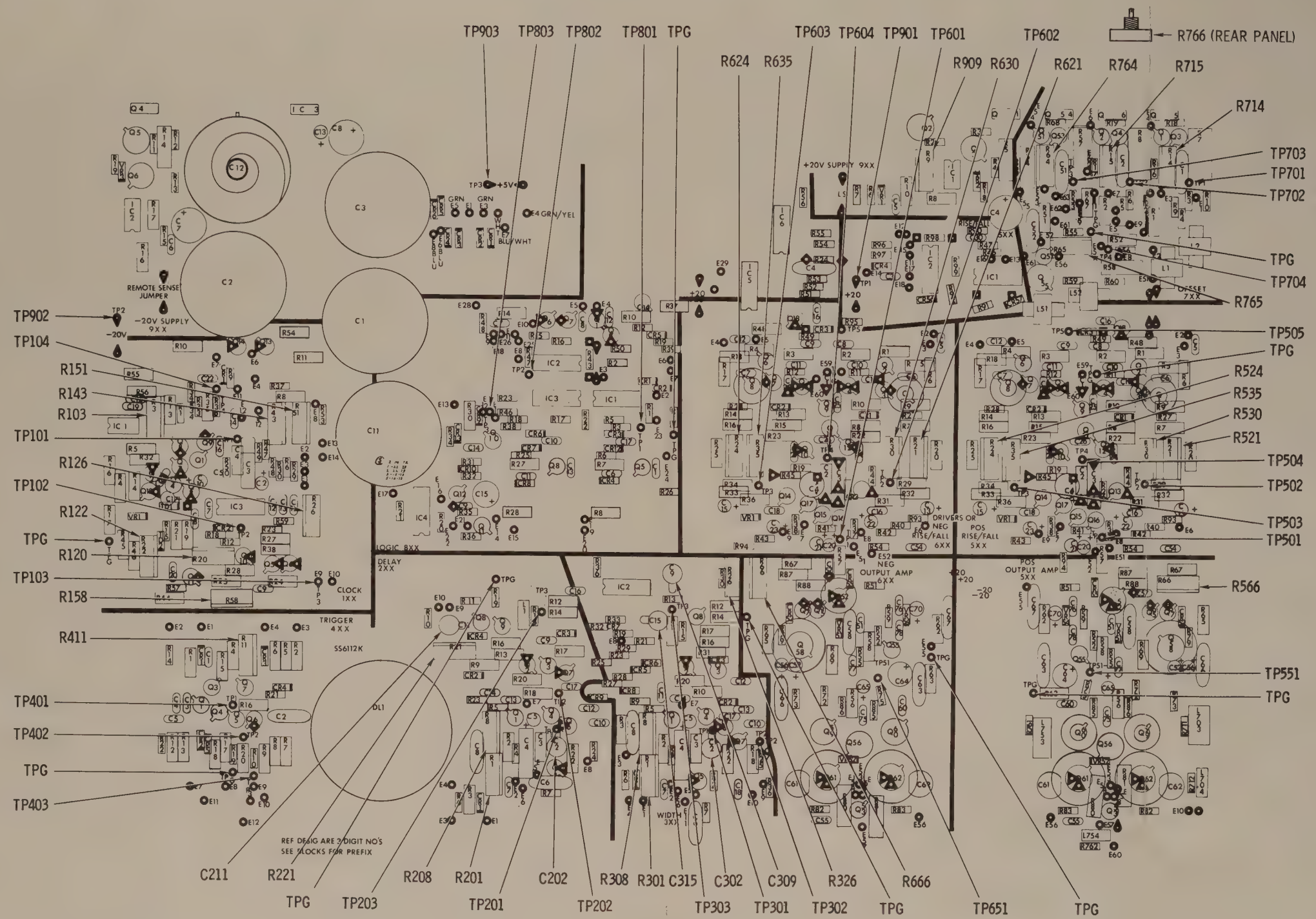


Figure 4-1. Adjustment and Test Point Location Diagram

Table 4-2. Calibration Test Procedure (Continued)

Step	Calibration	Control Setting	Test Equipment	Procedure	Equip. Spec.
10.1 (Cont)				3. Adjust REPETITION RATE vernier for ≈7 MHz on counter. 4. Adjust DELAY vernier for 40 nsec between pulses. 5. Adjust C315 to largest capacity which sets the first pulse to a width of 10 nsec. Adjust C309 so that the second pulse has approximately the same width as the first and 10 nsec.	
11.0	POLARITY OFFSET				
11.1	Polarity Offset Calibration	Std. except Mode: TRIGGER POLARITY: (-)	DVM (DC)	1. Connect DVM to OUTPUT with 50 ohm ±2% feedthrough load resistor. NOTE The unit should be allowed to warm up for at least 30 minutes in the case before making next adjustment. 2. Adjust R66 for 0.0 ±0.005 volts d.c. on the DVM.	

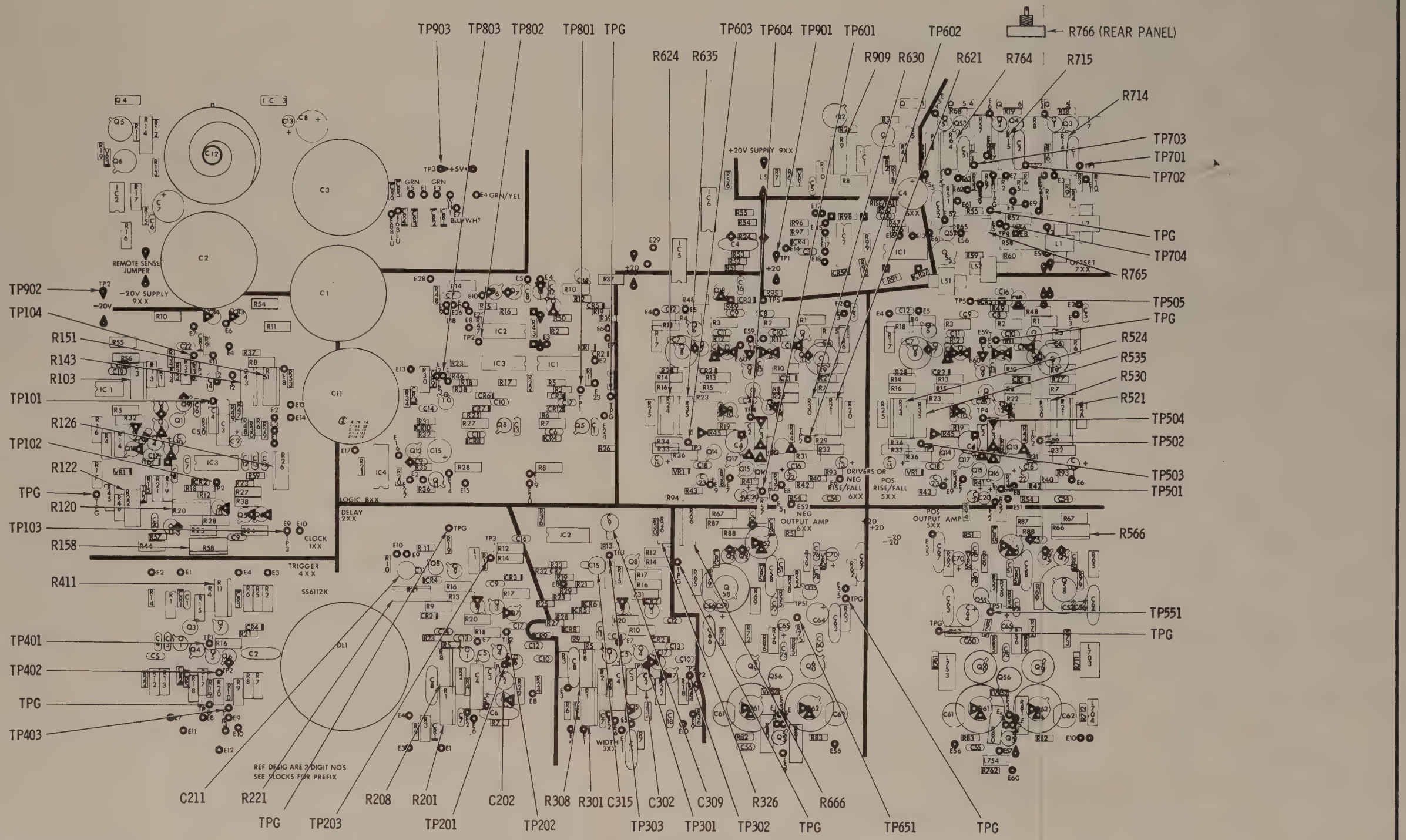


Figure 4-1. Adjustment and Test Point Location Diagram

Section 5
MAINTENANCE

5-1. INTRODUCTION

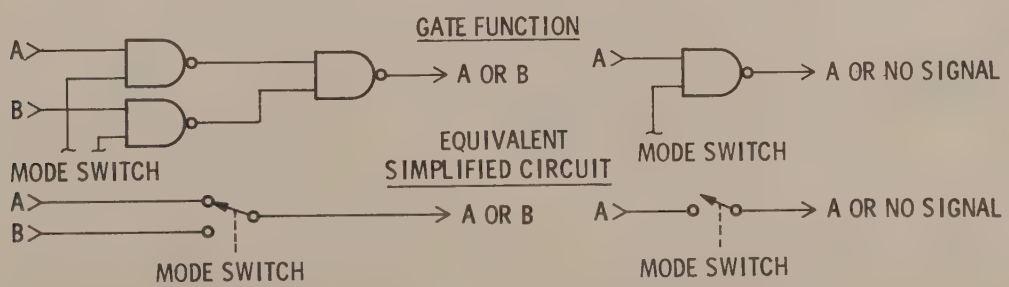
This section of your SERIES 20 manual will aid in isolating a malfunction to a particular section of the instrument. The schematic and circuit description section should therefore be reviewed for general design and operation fundamentals before attempting repair. Signal and d-c voltage levels are shown on the schematic diagrams in section 7. Test point and adjustment point locations are shown in section 4, figure 4-1.

5-2. FAULT ISOLATION

The signal flow within the instrument is mainly serial; i.e. the signal is cascaded from section to section, which eases the problem of fault isolation to a section. Each mode of operation, however, has a slightly different signal path. Signal flow diagrams for each of the seven modes are shown in figures 5-1 through 5-7. The signal flow diagrams show the signal flow to the mode steering gates. An additional diagram, figure 5-8 is used to show the output amplifier section which is the same for all modes. All modes of operation, except the GATE mode, can be tested fully without an external signal source. When testing the TRIGGER, TRIGGER DBL PULSE, or PULSE AMPLIFIER mode, connect a 50-ohm coaxial cable from the CLOCK OUTPUT to the INPUT. The clock is a free-running oscillator in these modes and can be used as an independent signal source. To exercise the GATE mode, disconnect the cable from the INPUT and press the MANUAL pushbutton.

5-3. LOGIC SECTION

A simplified description of the LOGIC section is shown in figure 5-9. This diagram can be useful in tracing the signal flow through the logic. The logic section uses TTL positive NAND gates to steer the signals to the proper outputs. Simplification of the LOGIC section has been made by replacing the gating arrangements with equivalent SPST or SPDT switches. An example of this simplification is as follows:



5-4. ASSEMBLY DRAWINGS

Component locations on the front panel, rear panel and attenuator assemblies are shown in figures 5-10 and 5-11. Component locations on the printed circuit board assembly as shown on the Test Point and Adjustment Point Location drawing (figure 4-1) in section 4.

5-5. SCHEMATIC DIAGRAMS

See section 7 of this manual for schematic diagrams.

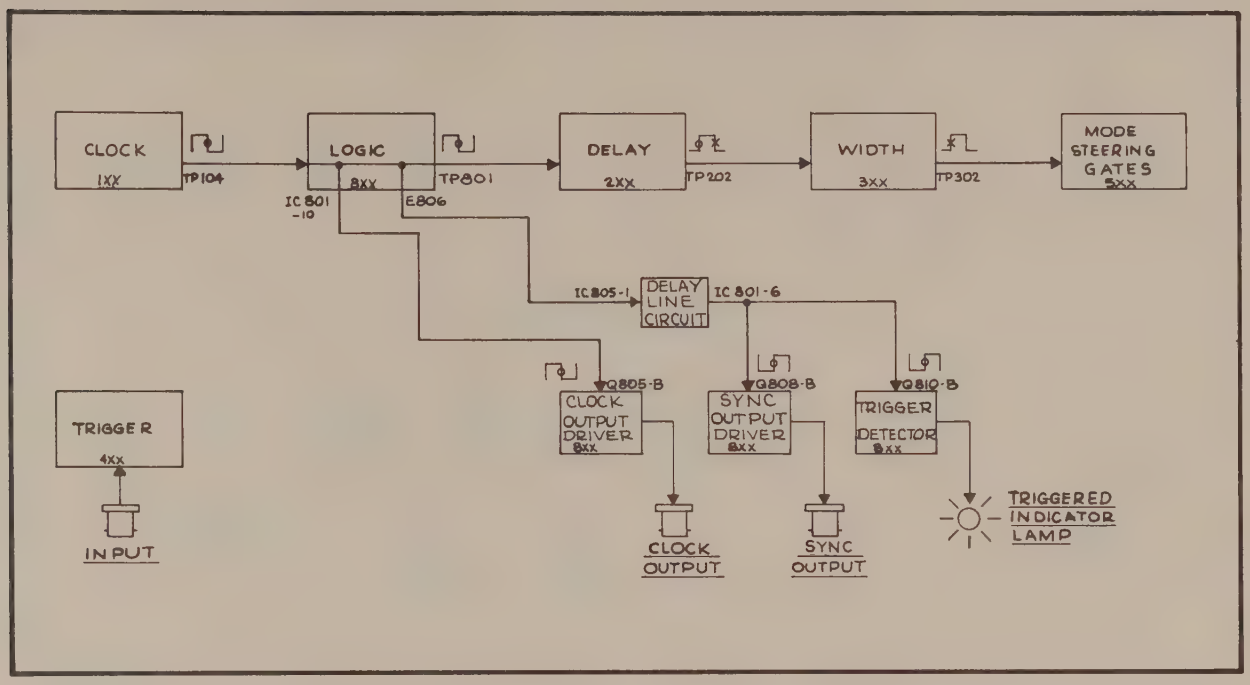


Figure 5-1. NORMAL Mode Signal Flow Diagram

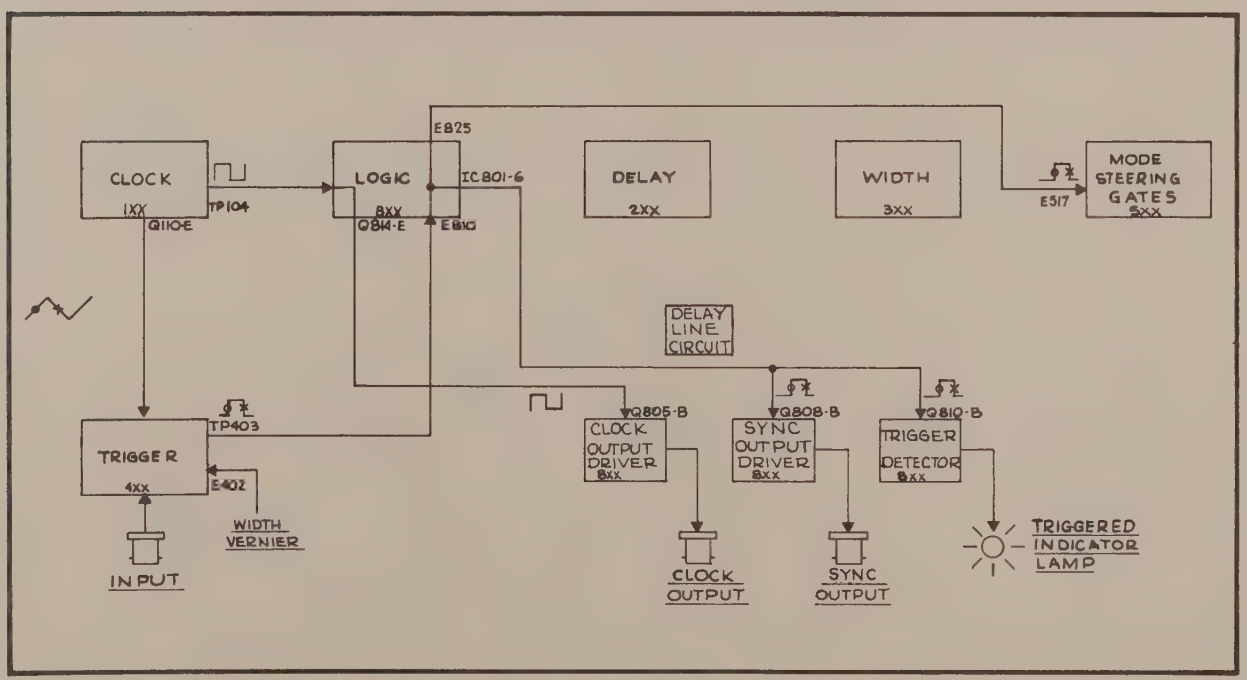


Figure 5-2. DUTY CYCLE Mode Signal Flow Diagram

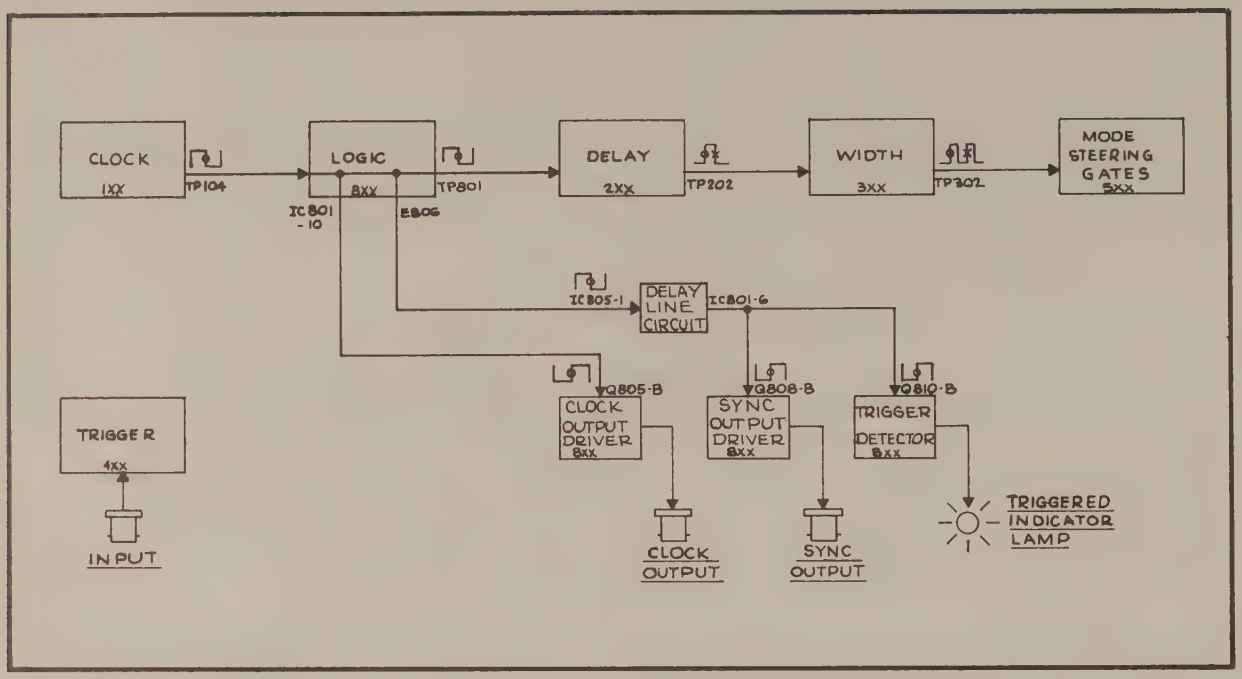


Figure 5-3. DBL PULSE Mode Signal Flow Diagram

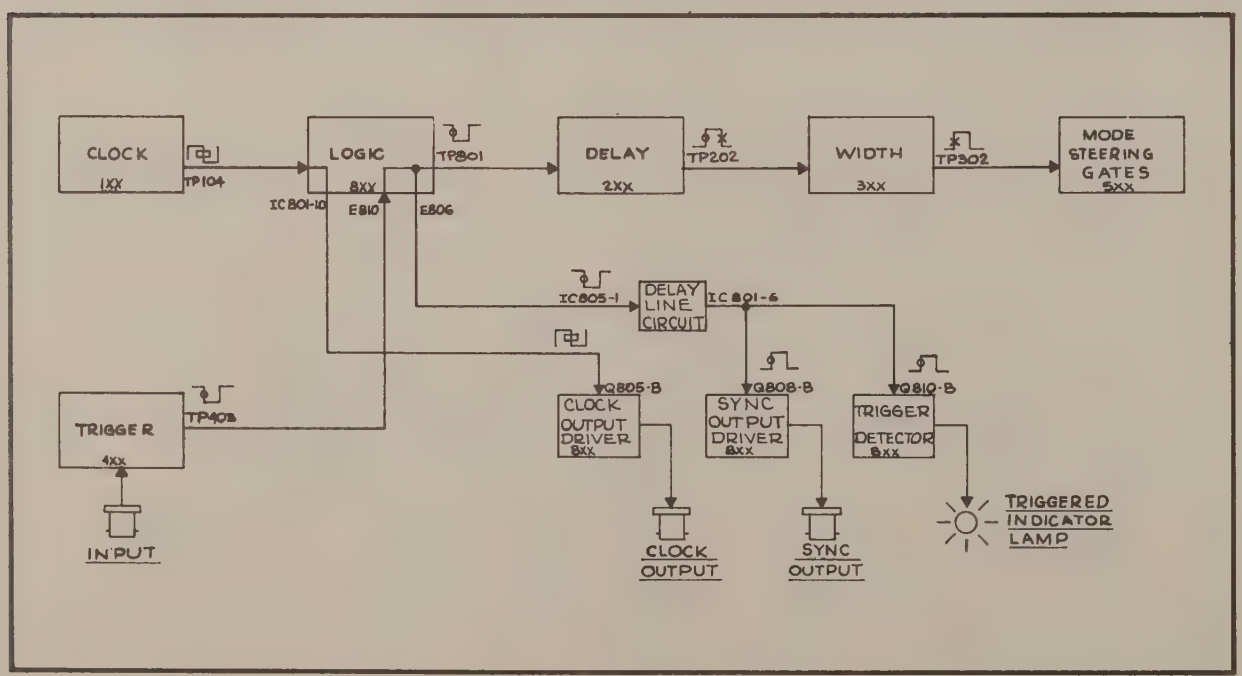


Figure 5-4. TRIGGER Mode Signal Flow Diagram

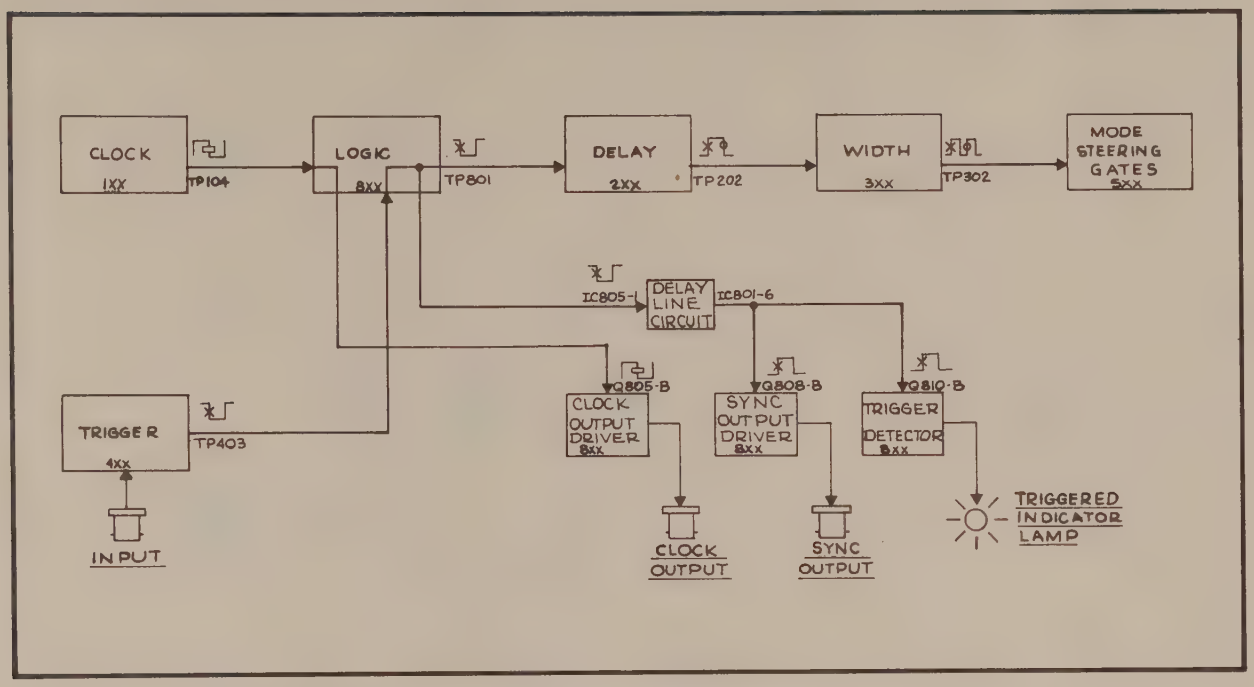


Figure 5-5. TRIGGER DBL PULSE Mode Signal Flow Diagram

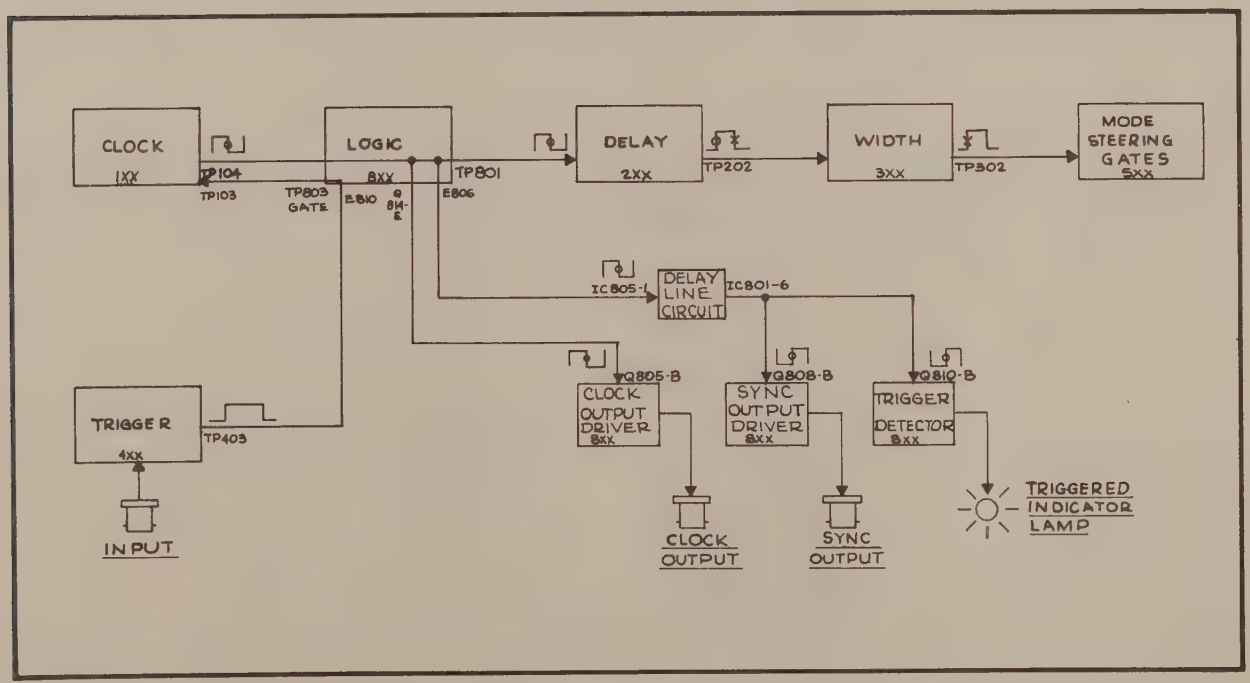


Figure 5-6. GATE Mode Signal Flow Diagram

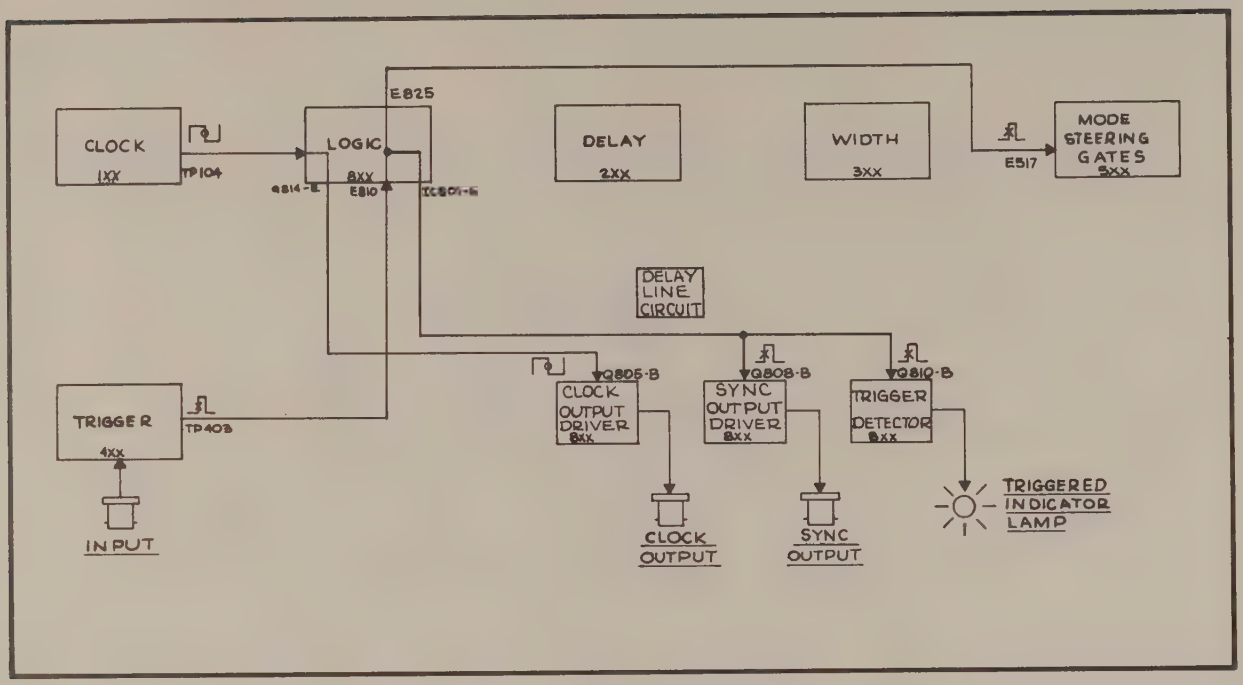


Figure 5-7. AMPLIFIER Mode Signal Flow Diagram

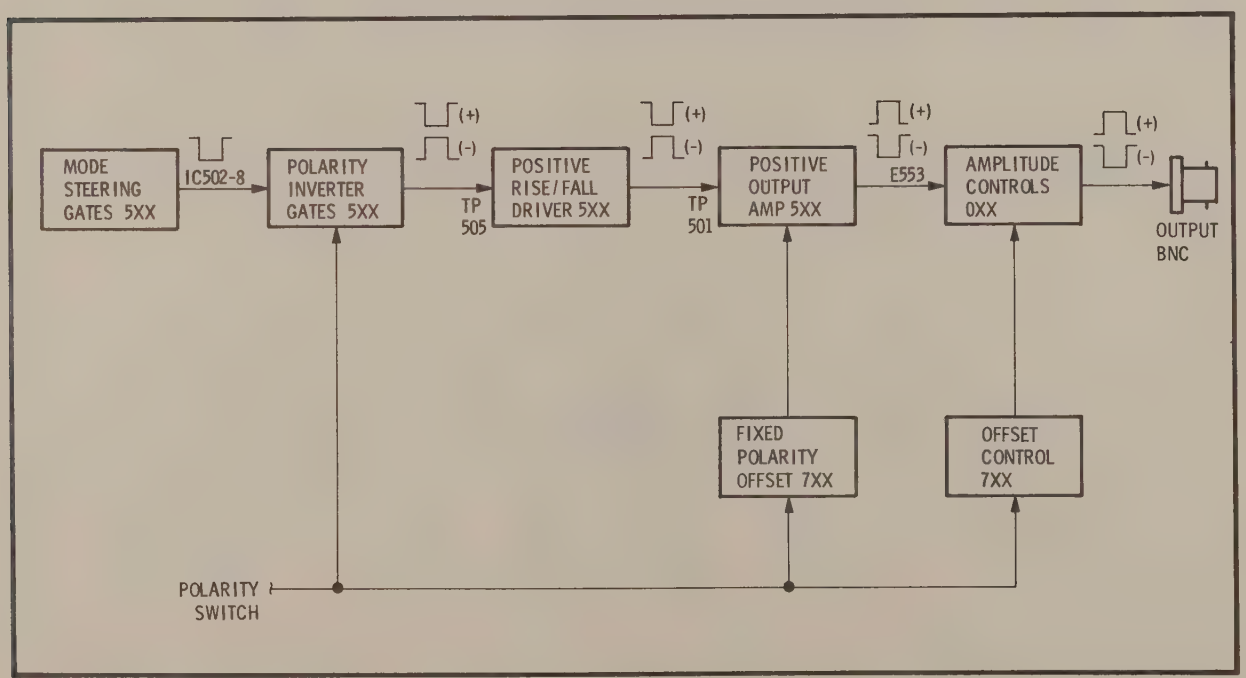


Figure 5-8. Output Signal Flow Diagram

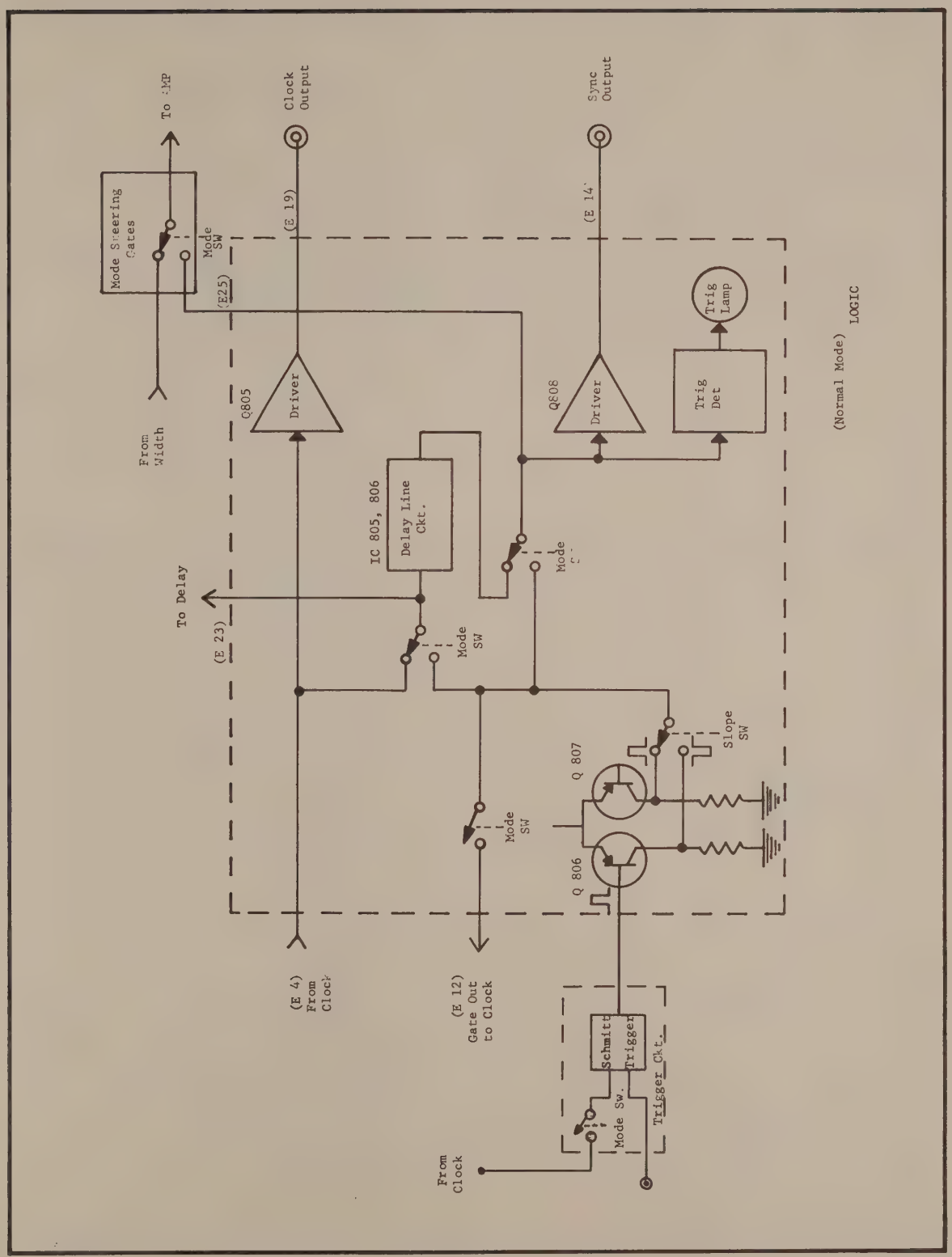


Figure 5-9. Simplified Logic Signal Flow Diagram

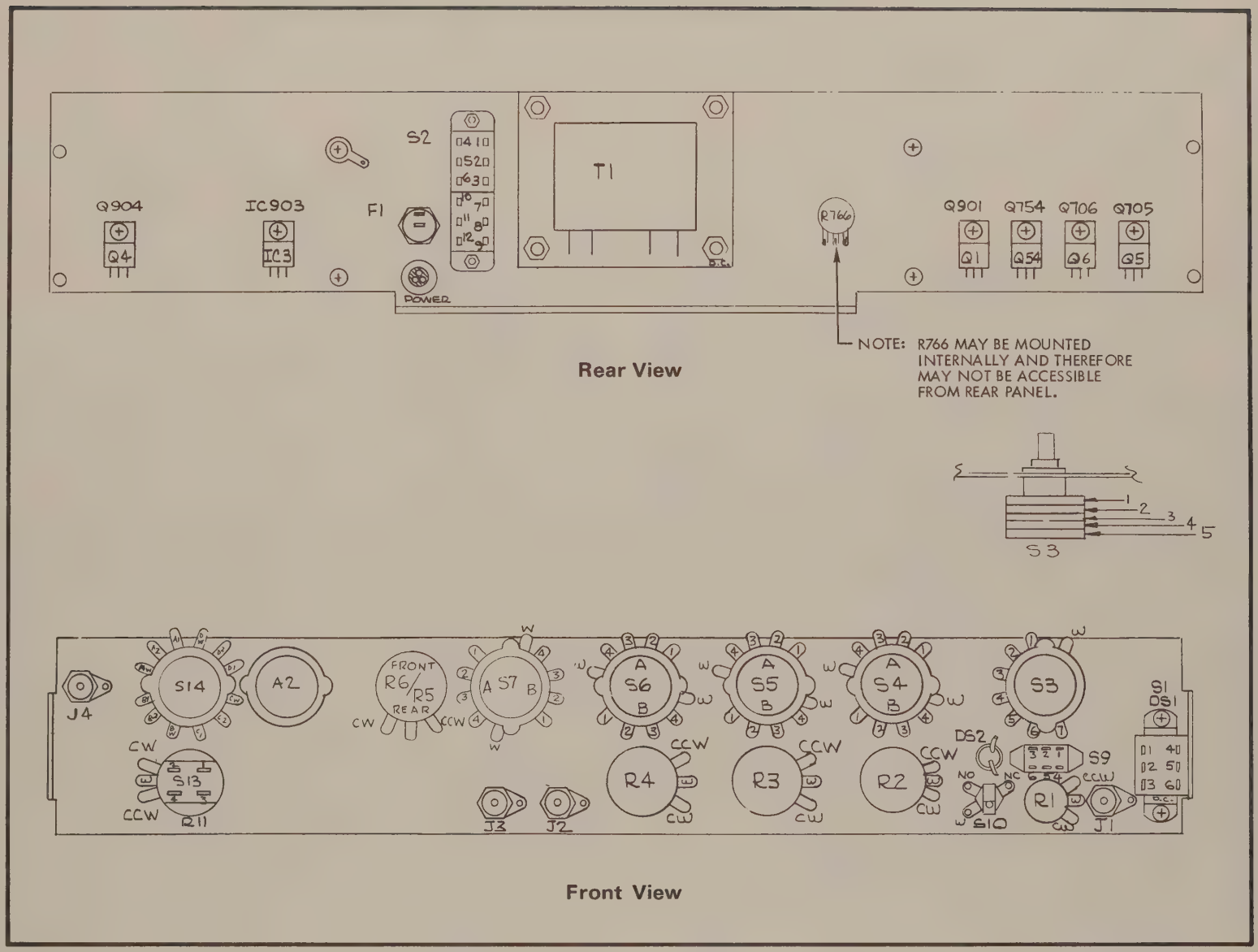


Figure 5-10. Front and Rear Panel Assembly

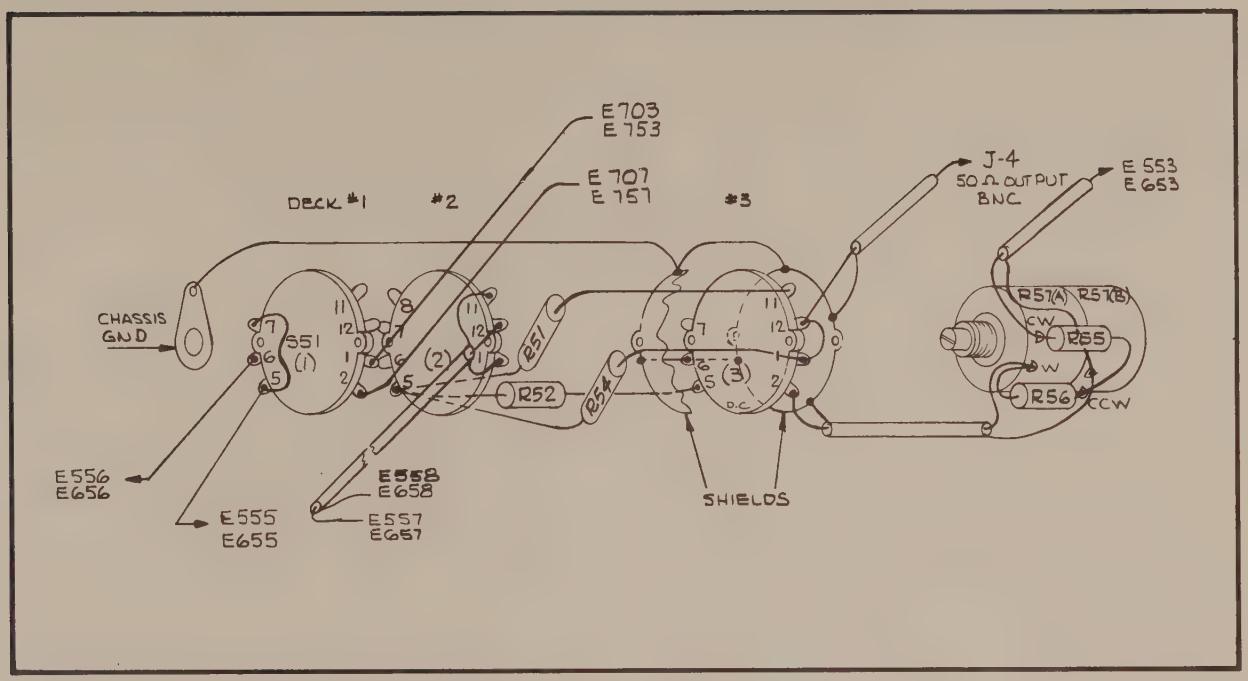


Figure 5-11. Attenuator Assembly

Section 6
PARTS LIST

6-1. INTRODUCTION

This section contains information for identifying and ordering replacement parts. Replacement parts may be ordered from Interstate Electronics Corporation. Be certain that the order or inquiry identifies the part by description and part number.

Table 6-1 is a listing of all mannufacturers supplying parts used in the function generator. Manufacturers are listed numerically by their respective code symbols.

6-2. PARTS LIST TABLE

Table 6-2 lists all electrical and electronic parts in alphanumeric order by reference designators and provides the following information for each part, where applicable: (a) value, (b) description, (c) manufacturer's code symbol, and (d) original manufacturer's part number.

TABLE 6-1. LIST OF MANUFACTURERS

Code	Manufacturer
01295	Texas Instruments Inc., Dallas, Texas
02735	RCA Corporation, Somerville, N. J.
04713	Motorola Semiconductor Products Inc., Phoenix, Arizona
07263	Fairchild Camera and Instrument Corporation, Mountain View, California
07421	Interstate Electronics Corporation, Anaheim, California
07994	American Radionic Co., Danbury, Connecticut
13103	Thermalloy Co., Dallas, Texas
22753	UID Electronics, Hollywood, Florida
28480	Hewlett-Packard Co., Palo Alto, California
56289	Sprague Electric Co., North Adams, Massachusetts
71590	Centralab, Milwaukee, Wisconsin
74950	E. F. Johnson Co., Waseca, Minnesota
75042	I R C Inc., Philadelphia, Pennsylvania
75915	Littelfuse Inc., Des Plaines, Illinois
76433	General Instrument Corporation, Newark, New Jersey
76493	J. W. Miller Co., Los Angeles, California
82389	Switchcraft Inc., Chicago, Illinois
84171	Arco Electronics Inc., Great Neck, New York
90201	Mallory Capacitor Co., Indianapolis, Indiana
91293	Johanson Mfg. Co., Boonton, N. J.

TABLE 6-2. PARTS LIST

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
C102	22μF	C: Electrolytic 6 volts ±10%	56289	196D226X9010KA1
C103	0.22μF	C: Film 100 volts ±10%	56289	C280MAH/A220K
C104	0.0022μF	C: Film 80 volts ±10%	56289	192P2229R8
C107	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C108	0.01μF	C: Ceramic 100 volts ±20%	71590	CM05ED-200J
C109	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C110	3.8μF	C: Electrolytic 35 volts ±10%	56289	196D685X0035KA1
C111	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C112	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C113	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C114	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C115	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C116	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C117	47μF	C: Electrolytic 6 volts ±10%	56289	196D476X9006KA1
C119	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C120	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C121	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C122	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C202	2.3-20pF	C: Variable 250 volts	91293	9302
C203	0.0047μF	C: Film 80 volts ±10%	56289	192P4729R8
C204	0.47μF	C: Film 100 volts ±10%	56289	C280MAH/A470K
C205	47μF	C: Electrolytic 6 volts ±10%	56289	196D473X9006KA1
C206	0.1μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C207	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C208	0.1μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C209	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C210	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C211	2.3-20pF	C: Variable 250 volts	91293	9302
C212	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C213	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C214	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C216	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C217		Factory Select	-----	F.S.
C302	2.3-20pF	C: Variable 250 volts	91293	9302
C303	0.0047μF	C: Film 80 volts ±10%	56289	192P4729R8
C304	0.47μF	C: Film 100 volts ±10%	56289	C280MAH/A470K
C305	47μF	C: Electrolytic 6 volts ±10%	56289	196D476X9006KA1
C306	0.1μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C307	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C308	0.1μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C309	3.8-30pF	C: Variable 250 volts	91293	9303
C310	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C311	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C312		Factory Select	-----	F.S.
C313	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C314	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
C315	2.3-20pF	C: Variable 250 volts	91293	9302
C317	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C318	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C401	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C402	0.01μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C403	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C404	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C405	20pF	C: Mica 500 volts ±10%	71590	CM05ED-200J
C501		Factory Select	-----	F.S.
C502	0.0047μF	C: Film 80 volts ±10%	71590	192P4729R8
C503	0.47μF	C: Film 100 volts ±10%	71590	C280MAH/A470K
C504	47μF	C: Electrolytic 20 volts ±10%	71590	196D476X9020LA3
C505	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C506		Factory Select	-----	F.S.
C507		Factory Select	-----	F.S.
C508	100pF	C: Mica 500 volts ±10%	84171	CM05ED-101J
C509	100pF	C: Mica 500 volts ±10%	84171	CM05ED-101J
C510	20pF	C: Mica 500 volts ±10%	84171	CM05ED-200J
C511	20pF	C: Mica 500 volts ±10%	84171	CM05ED-200J
C512	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C513	6.8μF	C: Electrolytic 35 volts ±10%	71590	196D685X0035KA1
C514	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C515	6.8μF	C: Electrolytic 35 volts ±10%	71590	196D685X0035KA1
C516	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C518	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C519	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C520	6.8μF	C: Electrolytic 35 volts ±10%	71590	196D685X0035KA1
C521	6.8μF	C: Electrolytic 35 volts ±10%	71590	196D685X0035KA1
C522	6.8μF	C: Electrolytic 35 volts ±10%	71590	196D685X0035KA1
C523	33μF	C: Electrolytic 6 volts ±10%	71590	196D336X9006KA1
C524		Factory Select	-----	F.S.
C525	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C526	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C527		Factory Select	-----	F.S.
C528	360pF	C: Mica 500 volts ±10%	84171	CM05ED-361J
C530	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C531	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C551	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C552	6.8μF	C: Electrolytic 35 volts ±10%	56289	196D695X0035KA1
C554		Factory Select		F.S.
C555	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C556	6.8μF	C: Electrolytic 35 volts ±10%	56289	196D685X0035KA1
C557		Factory Select	-----	F.S.
C558	0.1μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C560	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
C561	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C532	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C533	0.1μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C534	50μF	C: Electrolytic 25 volts -10% +100%	90201	MTV50CD25
C535	3.8μF	C: Electrolytic 35 volts ±10%	56289	196D685X0035KA1
C536	0.1μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C537	0.1μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C570	3.8μF	C: Electrolytic 35 volts ±10%	56289	196D685X0035KA1
C575	10pF	C: Mica 500 volts ±10%	84171	CM05ED-100J
C573	0.01	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C577	0.01	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C578		Factory Select	-----	F.S.
C701	0.1μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C702	0.1μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C801	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C804	0.1μF	C: Dip Mylar 50 volts ±40%	07994	FM0104U
C806	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C807	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C808	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C809	1000pF	C: Ceramic 600 volts ±10%	71590	DD-102
C810	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C811	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C812	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C813	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C814	51pF	C: Mica 500 volts ±10%	84171	CM05ED-510K
C815	50μF	C: Electrolytic 25 volts -10% +100%	90201	MTV50CD25
C817	0.01μF	C: Ceramic 100volts ±20%	71590	C023A101F103M
C901	2500μF	C: Electrolytic 35 volts -10% +150%	07421	P00347700
C902	2500μF	C: Electrolytic 35 volts -10% +150%	07421	P00347700
C903	2500μF	C: Electrolytic 35 volts -10% +150%	07421	P00347700
C904	100μF	C: Electrolytic 50 volts ±10%	90201	MTV100DN50
C905	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C906	0.01μF	C: Ceramic 100 volts ±20%	71590	C023A101F103M
C907	100μF	C: Electrolytic 50 volts ±10%	90201	MTV100DN50
C908	100μF	C: Electrolytic 15 volts ±10%	90201	20-44823
C911	2500μF	C: Electrolytic 35 volts -10% +150%	07421	P00347700
C912	2500μF	C: Electrolytic 35 volts -10% +150%	07421	P00347700
C913	6.8μF	C: Electrolytic 35 volts ±10%	56289	196D685X0035KA1
CR101		Diode: Silicon	07421	1N914A
CR102		Diode: Silicon Hot carrier	28480	HP5082-2835
CR201		Diode:Silicon	01295	1N4153
CR202		Diode: Silicon	01295	1N4153
CR203		Diode: Silicon	01295	1N4153
CR204		Diode: Silicon	07421	1N914A
CR301		Diode: Silicon	01295	1N4153
CR302		Diode: Silicon	01295	1N4153

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
CR303		Diode: Silicon	01295	1N4153
CR305		Diode: Silicon Hot Carrier	28480	HP5082-2835
CR306		Diode: Silicon Hot Carrier	28480	HP5082-2835
CR308		Diode: Silicon	07421	1N914A
CR309		Diode: Silicon	07421	1N914A
CR401		Diode: Silicon	01295	1N4153
CR402		Diode: Silicon	07421	1N914A
CR403		Diode: Silicon	07421	1N914A
CR404		Diode: Silicon	07421	1N914A
CR405		Diode: Silicon	07421	1N914A
CR501		Diode: Silicon	07421	1N914A
CR502		Diode: Silicon	07421	1N914A
CR503		Diode: Silicon Hot Carrier	28480	HP5082-2835
CR504		Diode: Silicon	07421	1N914A
CR552		Diode: Silicon	07421	1N914A
CR555		Diode: Silicon	01295	1N4153
CR556		Diode: Silicon	01295	1N4153
CR557		Diode:Silicon	01295	1N4153
CR801		Diode: Silicon	01295	1N4153
CR802		Diode: Silicon	01295	1N4153
CR803		Diode: Silicon	01295	1N4153
CR804		Diode: Silicon	01295	1N4153
CR805		Diode: Silicon	07421	1N914A
CR806		Diode: Silicon	01295	1N4153
CR807		Diode: Silicon	01295	1N4153
CR808		Diode: Silicon	01295	1N4153
CR809		Diode: Silicon	07421	1N914A
CR810		Diode: Silicon	07421	1N914A
CR811		Diode: Silicon	07421	1N914A
CR812		Diode: Silicon	01295	1N4153
CR813		Diode: Silicon	07421	1N914A
CR901		Diode: Silicon	04713	1N4002
CR902		Diode: Silicon	04713	1N4002
CR903		Diode: Silicon	04713	1N4002
CR904		Diode: Silicon	04713	1N4002
CR905		Diode: Silicon	04713	1N4002
CR906		Diode: Silicon	04713	1N4002
IC101		Integrated Circuit: 741 8-Pin Dip	01295	SN72741P
IC103		Integrated Circuit: 3086 14-Pin Dip	02735	CA3086
IC302		Integrated Circuit: 74S00 14-Pin Dip	01295	SN74S00N
IC501		Integrated Circuit: 74S00 14-Pin Dip	01295	SN74S00N
IC502		Integrated Circuit: 74S00 14-Pin Dip	01295	SN74S00N
IC801		Integrated Circuit: 74S00 14-Pin Dip	01295	SN74S00N
IC802		Integrated Circuit: 74S00 14-Pin Dip	01295	SN74S00N

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
IC803		Integrated Circuit: 74S00 14-Pin Dip	01295	SN74S00N
IC804		Integrated Circuit: 7400 14-Pin Dip	01295	SN7400N
IC805		Integrated Circuit: 74S00 14-Pin Dip	01295	SN74S04N
IC806		Integrated Circuit: 74S00 14-Pin Dip	01295	SN74S04N
IC901		Integrated Circuit: 741 8-Pin Dip	01295	SN72741P
IC902		Integrated Circuit: 741 8-Pin Dip	01295	SN72741P
IC903		Integrated Circuit:	04713	MC7805CP
L201	150nH	Choke	76493	9310-00
L301	150nH	Choke	76493	9310-00
L701	3.3mH	Choke	76493	73F333AF
L702	3.3mH	Choke	76493	73F333AF
L703	820μH	Choke	76493	9350-30
L704	33μH	Choke	76493	9310-52
L705	10μH	Choke	76493	9310-36
L751	3.3mH	Choke	76493	73F333AF
L752	3.3mH	Choke	76493	73F333AF
L753	820μH	Choke	76493	9350-30
L754	33μH	Choke	76493	9350-52
Q101		Transistor: Silicon PNP	07421	2N3906
Q102		Transistor: Silicon NPN	07263	2N5770
Q103		Transistor: Silicon NPN	07263	2N5770
Q104		Transistor: Silicon NPN	07421	2N3904
Q105		Transistor: Silicon NPN	07263	2N5769
Q106		Transistor: Silicon NPN	07263	2N5769
Q107		Transistor: Silicon NPN	07263	2N5769
Q108		Transistor: Silicon NPN	07263	2N5769
Q109		Transistor: Silicon PNP	07263	2N4258
Q110		Transistor: Silicon PNP	07263	2N4258
Q111		Transistor: Silicon NPN	07421	P00347008
Q112		Transistor: Silicon PNP	07263	2N4258
Q113		Transistor: Silicon NPN	07421	2N3904
Q114		Transistor: Silicon PNP	07421	2N3906
Q201		Transistor: Silicon PNP	01295	2N3251A
Q202		Transistor: Silicon PNP	07263	2N4258
Q203		Transistor: Silicon PNP	07263	2N4258
Q204		Transistor: Silicon NPN	07421	2N3904
Q205		Transistor: Silicon NPN	07421	2N3904
Q206		Transistor: Silicon PNP	07263	2N5771
Q207		Transistor: Silicon NPN	07263	2N5769
Q208		Transistor: Silicon NPN	07263	2N5769
Q209		Transistor: Silicon NPN	07263	2N5769
Q301		Transistor: Silicon PNP	01295	2N3251A
Q302		Transistor: Silicon PNP	07263	2N4258

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
Q303		Transistor: Silicon PNP	07263	2N4258
Q304		Transistor:Silicon NPN	07421	2N3904
Q305		Transistor: Silicon NPN	07421	2N3904
Q306		Transistor: Silicon PNP	07263	2N5771
Q307		Transistor: Silicon NPN	07263	2N5769
Q308		Transistor: Silicon NPN	07263	2N5769
Q401		Transistor: Silicon PNP	07421	2N3906
Q403		Transistor: Silicon PNP	07263	2N4258
Q404		Transistor: Silicon NPN	07421	2N3904
Q405		Transistor: Silicon NPN	07263	2N5769
Q406		Transistor: Silicon PNP	07263	2N4258
Q407		Transistor: Silicon PNP	07263	2N4258
Q501		Transistor: Silicon PNP	01295	2N3251A
Q502		Transistor: Silicon PNP	07263	2N5771
Q503		Transistor: Silicon PNP	07263	2N5771
Q504		Transistor: Silicon PNP	07263	2N5771
Q505		Transistor: Silicon NPN	07263	2N5769
Q506		Transistor: Silicon NPN	07263	2N5769
Q507		Transistor: Silicon NPN	07263	2N5769
Q508		Transistor: Silicon NPN	04713	2N2369
Q509/Q511		Transistor: Matched Pair NPN/ PNP	07421	P00347099
Q510		Transistor: Silicon NPN	07263	2N5769
Q512		Transistor: Silicon PNP	07263	2N5771
Q513		Transistor: Silicon NPN	07263	2N5769
Q514		Transistor: Silicon PNP	07263	2N5771
Q515		Transistor: Silicon PNP	07421	2N3906
Q516		Transistor: Silicon PNP	07421	2N3906
Q517		Transistor: Silicon PNP	07421	2N3906
Q518		Transistor: Silicon NPN	07263	2N5769
Q552		Transistor: Silicon NPN	02735	2N5109
Q553		Transistor: Silicon PNP	04713	MPS404A
Q554		Transistor: Silicon NPN	07263	2N5769
Q555		Transistor: Silicon NPN	04713	2N2369
Q556		Transistor: Silicon PNP	04713	2N2905A
Q557		Transistor: Silicon NPN	07421	2N3904
Q558		Transistor: Silicon NPN	04713	2N2219A
Q559		Transistor: Silicon PNP	07421	P00347107
Q560		Transistor: Silicon PNP	07421	P00347107
Q561		Transistor: Silicon PNP	04713	MM4018
Q562		Transistor: Silicon PNP	04713	MM4018
Q564		Transistor: Silicon NPN	07263	2N5769
Q565		Transistor: Silicon PNP	07421	2N3906
Q701		Transistor: Silicon NPN	07421	2N3904
Q702		Transistor: Silicon PNP	07421	2N3906
Q703		Transistor: Silicon PNP	07421	2N3906

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
Q704		Transistor: Silicon NPN	07421	2N3904
Q705		Transistor: Silicon NPN	01245	TIP30A
Q706		Transistor: Silicon PNP	01295	TIP29A
Q751		Transistor: Silicon NPN	07421	2N3904
Q801		Transistor: Silicon PNP	07263	2N5771
Q802		Transistor: Silicon PNP	07263	2N5771
Q805		Transistor: Silicon NPN	07421	P00347002
Q806		Transistor: Silicon PNP	07263	2N5771
Q807		Transistor: Silicon PNP	07263	2N5771
Q808		Transistor: Silicon NPN	07421	P00347002
Q810		Transistor: Silicon NPN	07263	2N5769
Q811		Transistor: Silicon PNP	01295	2N3251A
Q812		Transistor: Silicon NPN	07263	2N5769
Q814		Transistor: Silicon NPN	07263	2N5769
Q901		Transistor: Silicon PNP	01295	TIP31
Q902		Transistor: Silicon NPN	04713	2N2219A
Q903		Transistor: Silicon NPN	04713	2N2219A
Q904		Transistor: Silicon PNP	01295	TIP32
Q905		Transistor: Silicon PNP	04713	2N2905A
Q906		Transistor: Silicon PNP	04713	2N2905A
R1	5K	Control, Level 1/4 watt ±10%	07421	PR0347680B
R2	5K	Vern, Rep Rate 1/2 watt ±10%	07421	PR0347681A
R3	5K	Vern, Delay 1/2 watt ±10%	07421	PR0347682B
R5/R6	50K Dual	Vern, Rise/Fall	07421	PR0347683D
R11	5K		07421	
R51	33	R: Metal Glaze 1 watt ±5%	74052	RG32-330J
R52	20	R: Metal Glaze 1 watt ±5%	74052	RG32-200J
R54	33	R: Metal Glaze 2 watt ±5%	74052	RG42-330J
R55	51	R: Metal Glaze 2 watt ±5%	75042	RG42-510J
R56	51	R: Metal Glaze 2 watt ±5%	75042	RG42-510J
R57	50	R: Variable, Bridged T Pad	07421	PR0347684C
R101	7.5Meg	R: Carbon 1/2 watt ±5%	75042	RC07GF755J
R103	10K	R: Variable 1/4 watt ±30%	71590	TSV-10K
R104/R105	15K	R: Matched Set 1/2 watt ±1%	07421	P00347616-1502
R106	1K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-102J
R107		Factory Select	-----	F.S.
R108	5.62K	R: Metal Film 1/2 watt ±1%	01295	MC60D-5621F
R109	150K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-154J
R110	976	R: Metal Film 1/2 watt ±1%	01295	MC60D-9760F
R111	357	R: Metal Film 1/2 watt ±1%	01295	MC60D-3570F
R112	7.5K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-752J
R113	2.00K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2001F
R114	49.9	R: Metal Film 1/2 watt ±1%	01295	MC60D-49R9F
R115	680	R: Metal Glaze 1/4 watt ±5%	75042	RG-1/4-681J
R116	487	R: Metal Glaze 1/2 watt ±1%	01295	MC60D-4870F
R117	15K	R: Metal Glaze 1/2 watt ±1%	01295	MC60D-1502F

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
R118	51	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-510J
R119	.107	R: Metal Film 1/2 watt ±1%	01295	MC60D-1070F
R120	100	R: Variable 1/4 watt ±30%	71590	TSV-100
R121	357	R: Metal Film 1/2 watt ±1%	01295	MC60D-3570F
R122	250	R: Variable 1/4 watt ±30%	71590	TSV-250
R123	2.4K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-242J
R124	4.64K	R: Metal Film 1/2 watt ±1%	01295	MC60D-4641F
R125	1.30K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1301F
R126	500	R: Variable 1/4 watt ±30%	71590	TSV-500
R127	221	R: Metal Film 1/2 watt ±1%	01295	MC60D-2210F
R128	1.82K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1821F
R129	1K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-102J
R130	1K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-102J
R132	1.58K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1581F
R133	15K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-153J
R134	200	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-201J
R135	1.5K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-152J
R136	390	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-390J
R137	200	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-201J
R138	750	R: Metal Glaze 1/2 watt ±5%	75042	RG20-751J
R143	10K	R: Variable 1/4 watt ±30%	71590	TSV-10K
R144	2.00K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2001F
R145	887	R: Metal Film 1/2 watt ±1%	01295	MC60D-8870F
R146	357	R: Metal Film 1/2 watt ±1%	01295	MC60D-3570F
R147	470K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-474J
R148	470K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-474J
R149	470K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-474J
R150	470K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-474J
R151	25K	R: Variable 1/4 watt ±30%	71590	TSV-25K
R153	3.3K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-332J
R154	7.50K	R: Metal Film 1/2 watt ±1%	01295	MC60D-7501F
R155/R156	15.0K	R: Matched Set 1/2 watt ±1%	07421	P00347616-1502
R157	82K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-823J
R158	50K	R: Variable 1/4 watt ±30%	71590	TSV-50K
R159	4.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-472J
R201	1K	R: Variable 1/4 watt ±30%	71590	TSV-1K
R202	1.10K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1101F
R203	4.32	R: Metal Film 1/2 watt ±1%	01295	MC60D-4321F
R204	100	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-101J
R205	150K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-154J
R206	3.3K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-332J
R207	390	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-391J
R208	50K	R: Variable 1/4 watt ±30%	71590	TSV-50K
R209	200	R: Metal Film 1/2 watt ±1%	01295	MC60D-2000F
R210	2K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-202J
R211	10K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-103J

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
R212	309	R: Metal Film 1/2 watt ±1%	01295	MC60D-3090F
R213	1.00K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1001F
R214	49.9	R: Metal Film 1/2 watt ±1%	01295	MC60D-49R9F
R215	68	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-680J
R216	910	R: Metal Glaze 1/2 watt ±5%	75042	RG20-911J
R217	107	R: Metal Film 1/2 watt ±1%	01295	MC60D-1070F
R218	1K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-102J
R219	200	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-201J
R220	1.47K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1471F
R221	500	R: Variable 1/4 watt ±30%	71590	TSV-500
R222	178	R: Metal Film 1/2 watt ±1%	01295	MC60D-1780F
R223	120K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-124J
R224	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R225	51	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-510J
R236		Factory Select	-----	F.S.
R301	1K	R: Variable 1/4 watt ±30%	71590	TSV-1K
R302	1.10K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1101F
R303	4.32K	R: Metal Film 1/2 watt ±1%	01295	MC60D-4321F
R304	100	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-101J
R305	150K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-154J
R306	3.3K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-332J
R307	390	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-391J
R308	50K	R: Variable 1/4 watt ±30%	71590	TSV-50K
R309	120K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-124J
R310	200	R: Metal Film 1/2 watt ±1%	01295	MC60D-2000F
R312	309	R: Metal Film 1/2 watt ±1%	01295	MC60D-3090F
R313	100	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-101J
R314	49.9	R: Metal Film 1/2 watt ±1%	01295	MC60D-49R9F
R315	680	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-680J
R316	910	R: Metal Glaze 1/2 watt ±5%	75042	RG20-911J
R317	107	R: Metal Film 1/2 watt ±1%	01295	MC60D-1070F
R318	1K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-102J
R319	4.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-472J
R320	1.47K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1471F
R321	4.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-472J
R322	178	R: Metal Film 1/2 watt ±1%	01295	MC60D-1780F
R323	390	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-391J
R324	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R325	51	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-510J
R326	500	R: Variable 1/4 watt ±30%	71590	TSV-500
R327	390	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-391J
R328	360	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-361J
R329	360	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-361J
R330	200	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-201J
R331	1.00K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1001F
R332	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
R333	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R336		Factory Select	-----	F.S.
R401	806	R: Metal Film 1/2 watt ±1%	01295	MC60D-8060F
R402	4.32K	R: Metal Film 1/2 watt ±1%	01295	MC60D-4321F
R404	150	R: Metal Film 1/2 watt ±1%	01295	MC60D-1500F
R405	715	R: Metal Film 1/2 watt ±1%	01295	MC60D-7150F
R406	5.11K	R: Metal Film 1/2 watt ±1%	01295	MC60D-5111F
R407	200	R: Metal Film 1/2 watt ±1%	01295	MC60D-2000F
R408	15.0K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1502F
R409	1.5K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-152J
R410	39	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-390J
R411	250	R: Variable 1/4 watt ±30%	71590	TSV-250
R412	2.00K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2001F
R413	2.00K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2001F
R414	100	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-101J
R415	1.15K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1151F
R416	2.00K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2001F
R417	2.00K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2001F
R418	3.57K	R: Metal Film 1/2 watt ±1%	01295	MC60D-3571F
R419	62	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-620J
R420	1.82K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1821F
R421	1K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-102J
R422	51	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-510J
R501	1.78	R: Metal Film 1/2 watt ±1%	01295	MC60D-1781F
R502	357	R: Metal Film 1/2 watt ±1%	01295	MC60D-3570F
R503	348	R: Metal Film 1/2 watt ±1%	01295	MC60D-3480F
R504	1.05K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1051F
R506	250	R: Metal Film 1/2 watt ±1%	01295	MC60D-2150F
R507	3.01K	R: Metal Film 1/2 watt ±1%	01295	MC60D-3011F
R508	2.21K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2211F
R509	2.37K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2371F
R510	619	R: Metal Film 1/2 watt ±1%	01295	MC60D-6190F
R511	68	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-680J
R512	68	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-680J
R513	619	R: Metal Film 1/2 watt ±1%	01295	MC60D-6190F
R514	2.37	R: Metal Film 1/2 watt ±1%	01295	MC60D-2371F
R515	2.21K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2211F
R516	3.01K	R: Metal Film 1/2 watt ±1%	01295	MC60D-3011F
R517	215	R: Metal Film 1/2 watt ±1%	01295	MC60D-2150F
R519	470K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-474J
R520	2.43K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2431F
R521	100	R: Variable 1/4 watt ±30%	71590	TSV-100
R522	365	R: Metal Film 1/2 watt ±1%	01295	MC60D-3650F
R523	365	R: Metal Film 1/2 watt ±1%	01295	MC60D-3650F
R524	100	R: Variable 1/4 watt ±30%	71590	TSV-100
R525	2.43K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2431F

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
R526	470K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-474J
R527	10K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-103J
R528	10K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-103J
R529	4.99K	R: Metal Film 1/2 watt ±1%	01295	MC60D-4991F
R530	500	R: Variable 1/4 watt ±30%	71590	TSV-500
R531	200	R: Metal Film 1/2 watt ±1%	01295	MC60D-2000F
R532	1.5K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-152J
R533	1.5K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-152J
R534	4.99K	R: Metal Film 1/2 watt ±1%	01295	MC60D-4991F
R535	500	R: Variable 1/4 watt ±30%	71590	TSV-500
R536	200	R: Metal Film 1/2 watt ±1%	01295	MC60D-2000F
R537	5.6	R: Carbon 1/4 watt ±5%	75042	RC07GF5R6J
R538	5.6	R: Carbon 1/4 watt ±5%	75042	RC07GF5R6J
R540	150	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-151J
R541	4.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-472J
R542	4.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-472J
R543	4.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-472J
R544	39	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-390J
R545	39	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-390J
R548	1.3K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-132J
R549	15	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-150J
R551	2.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-272J
R552	200	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-201J
R553	51.1	R: Metal Film 1/2 watt ±1%	01295	MC60D-51R1F
R554		Factory Select	-----	F.S.
R555	1.6K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-162J
R556	51.1	R: Metal Film 1/2 watt ±1%	01295	MC60D-51R1F
R557	60.4	R: Metal Film 1/2 watt ±1%	01295	MC60D-60R4F
R558	82.5	R: Metal Film 1/2 watt ±1%	01295	MC60D-82R5F
R559		Factory Select	-----	F.S.
R562	2.00K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2001F
R563	2.43K	R: Metal Film 1/2 watt ±1%	01295	MC60-2431F
R564	511	R: Metal Film 1/2 watt ±1%	01295	MC60-5110F
R565	100	R: Metal Film 1/2 watt ±1%	01295	MC60D-1000F
R566	500	R: Variable 1/4 watt ±30%	71590	TSV-500
R567	2.00K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2001F
R569	1.1K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-112J
R572		Factory Select	-----	R.S.
R573	1.6K	R: Metal Film, 1/4 watt ±5%	75042	RG1/4-162J
R575		Factory Select	-----	F.S.
R578	200	R: Metal Film 1/2 watt ±1%	01295	MC60D-2000F
R579	300	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-301J
R580	100	R: Metal Film 1 watt ±1%	75042	MEB-TO-1000D
R581	100	R: Metal Film 1 watt ±1%	75042	MEB-TO-1000D
R582	120K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-124J
R583	1.8K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-182J

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
R585		Factory Select	-----	F.S.
R586		Factory Select	-----	F.S.
R587	309	R: Metal Film 1/2 watt ±1%	01295	MC60D-3090F
R588	309	R: Metal Film 1/2 watt ±1%	01295	MC60D-3090F
R590	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R591	2K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-202J
R592	2K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-202J
R593	18K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-183J
R594	18K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-183J
R595	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R596	2K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-202J
R597	2K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-202J
R598	2.7	R: Carbon 1/4 watt ±5%	75042	RC07GF2R7J
R599	2K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-202J
R701	15K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1502F
R702	15K	R: Metal Film 1/2 watt ±1%	01295	MC60D-1502F
R703	1K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-102J
R704	1.5K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-152J
R705	560	R: Metal Glaze 1/2 watt ±5%	75042	RG20-561J
R706	1K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-102J
R707	18	R: Metal Glaze 2 watt ±5%	75042	RC42GF180J
R708	18	R: Metal Glaze 2 watt ±5%	75042	RC42GF180J
R710	2.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-272J
R711	2.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-272J
R712	2.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-272J
R713	1.5K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-152J
R714	10K	R: Variable 1/4 watt ±5%	71590	TSV-10K
R715	10K	R: Variable 1/4 watt ±5%	71590	TSV-10K
R718	1K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-102J
R719	1K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-102J
R754	560	R: Metal Glaze 1 watt ±5%	75042	RG32-561J
R755	1.5K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-152J
R757	18	R: Carbon 2 watt ±5%	75042	RC42GF180J
R759	3.3K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-332J
R760	2.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-272J
R761	2.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-272J
R762	2.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-272J
R767	402	R: Metal Film 1/4 watt ±1%	01295	MC60D-4020F
R801	360	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-361J
R802	360	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-361J
R803	47	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-470J
R805	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R806	18	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-180J
R807	1.3K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-132J
R808	47	R: Metal Glaze 1/2 watt ±5%	75042	RG20-470J
R810	1K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-102J

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
R811	200	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-201J
R812	270	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-271J
R814	1K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-102J
R815	220	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-221J
R816	220	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-221J
R817	2.2K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-222J
R818	4.3K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-432J
R819	4.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-472J
R820	2K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-202J
R821	2K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-202J
R822	2K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-202J
R823	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R824	2.7	R: Carbon 1/4 watt ±5%	75042	RC07GF2R7J
R825	18	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-180J
R826	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R827	1.5K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-152J
R828	47	R: Metal Glaze 1/2 watt ±5%	75042	RG20-470J
R830	1.5K	R: Metal Glaze 1/2 watt ±5%	75042	RG20-152J
R831	3.3K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-332J
R832	330	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-331J
R834	10K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-103J
R835	4.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-472J
R836	1.2K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-122J
R838	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R839	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R843	2.7	R: Carbon 1/4 watt	75042	RC07GF2R7J
R846	47	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-470J
R847	47	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-470J
R848	56	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-560J
R850	47	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-470J
R851	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R852	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R853	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R854	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R855	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R856	560	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-561J
R902	2.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-272J
R903	330	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-331J
R904	10K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-103J
R905	1	R: Wirewound 2 watt ±5%	75042	BWH-1R0J
R906	3K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-302J
R907	3K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-302J
R908	9.09K	R: Metal Film 1/2 watt ±1%	01295	MC60D-9091
R909	1K	R: Variable 1/4 watt ±30%	71590	TSV-1K
R910	2.94K	R: Metal Film 1/2 watt ±1%	01295	MC60D-2941
R911	2.7K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-272J

Table 6-2. Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	MFG CODE	PART NUMBER
R912	330	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-331J
R913	10K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-103J
R914	1	R: Wirewound 2 watt ±5%	75042	BWH-1R0J
R915	7.5K	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-752J
R916/R917	15.0K	R: Matched Set 1/2 watt ±1%	01295	MC60D-1502
R918	470	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-471J
R919	470	R: Metal Glaze 1/4 watt ±5%	75042	RG1/4-471J
S1/DS1		Switch, Power	22753	LRSW322-N-125CL
S3		Switch, Mode	07421	PR0347920B
S4		Switch, Multivib	07421	PR0347921A
S5		Switch, Delay	07421	PR0347921A
S6		Switch, Width	07421	PR0347921A
S7		Switch, Rise/Fall	07421	PR0347921A
S9		Switch, Slope (STACKPOLE P/N)	78488	SS-91-1-440THD
S10		Switch	82389	963
S13/R11		Control, Offset	07421	PR0347923B
S2		Switch, Slide	07421	PR0347926B
S51		Switch	07421	PR0347925G
S14		Switch, Polarity	07421	PR0347924C
TD101		Diode: Tunnel	07421	P00347302
TD102		Diode: Tunnel	07421	P00347302
VR101		Diode: Zener 5.1V	07421	1N5231B
VR501		Diode: Zener 10.0V	07421	1N5240B
VR551		Diode: Zener 8.2V	07421	1N4738A
VR554		Diode: Zener 2.4V	07421	1N5221B
VR901		Diode: Zener 5.1V	07421	1N5231B
VR902		Diode: Zener 15.0V	07421	1N5245
VR903		Diode: Zener 15.0V	07421	1N4245
DS2		Lamp, Triggered 28 volts 40 ma Green	MURA	L28/40-G
F1	0.75 amp	Fuse, Slo Blo for 115V	75915	313.750
F1	0.37 amp	Fuse, Slo Blo for 230V	75915	313.375
T1		Transformer, Power	07421	PR0347801H

NOTES

Section 7
SCHEMATIC DIAGRAMS

7-1. INTRODUCTION

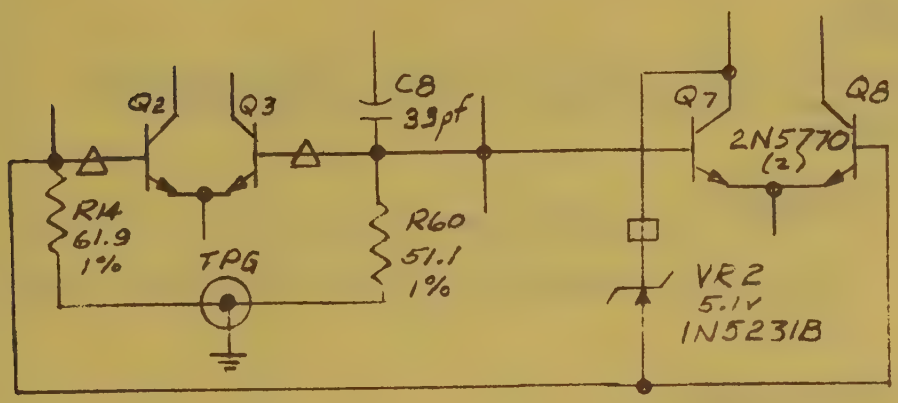
Three schematc diagrams are provided: Figure 7-1 applies to all SERIES 20 Pulse Generators. Figure 7-2 shows the output section of the P22 generator, and figure 7-3 shows the output section of the P24 generator.

NOTES

ERRATA PAGE (February 5, 1975)

Clock Circuit Modification (1XX)

The modified circuit is shown below. Refer to Input Circuit Schematic Figure 7-1, Box 1XX.



In Parts List Table 6-2:

Delete: TD101, TD102, Q112

Add: R160, 51.1 ohms, Metal Film, 1/2W, 1%, MC60D-51R1F
VR102, 5.1v, Diode: Zener, 1N5231B

Change: C108 to 33pf, Mica, 500v, 10%, CM05ED330K
Q107 to 2N5770
Q108 to 2N5770
R114 to 61.9 ohms, Metal Film, 1/2W, 1%, MC60D-61R9F

ERRATA PAGE

Issued February 5, 1975

APPLIES TO ALL SERIES 20 PULSE GENERATORS

SCHEMATIC ERROR

Two resistors in the logic (8XX) circuit are shown improperly. Correct Input Schematic Figure 7-1 and Parts List Table 6-2 as follows:

On Schematic:

Remove resistor R838 shown connecting IC801 to +5 volts.

Rename R829 (connected to Q810 base) as R838 with value of 560 ohms.

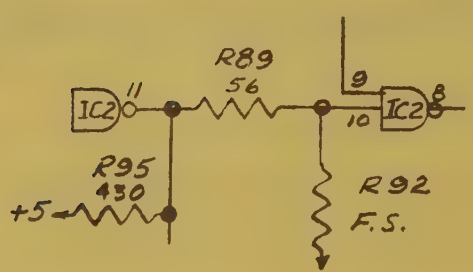
In Parts List:

Delete R829

Certain generators having Serial Numbers above 202 may contain either or both of the circuit modifications described below. These modifications were made to allow the use of more readily available components. They cause no change in performance or specifications.

Rise/Fall Circuit Modification

Circuit Schematic Figure 7-1, Box 5XX, correct as follows:



In Parts List Table 6-2:

Delete:	CR556
Add:	R589, 56 ohms, Metal Glaze, 1/4W, 5%, RG1/4-560v
Change:	R592 to F.S. (factory select)
	R595 to 430 ohms, Metal Glaze, 1/4W, 5%, RG1/4-431J

TO REMOTE SENSE POWER SUPPLY 9XX

(+13.5V TO +20V CONTROLLED BY R2)

MAX FREQ ADJ.

REP RATE VERN R2

MIN FREQ ADJ.

REPITITION RATE RANGE S4

CCW 1-100HZ .10-10KHZ .01-1MHZ CW

S4-A 1-50MHZ

S4-B 50 MHz ADJ

SYM ADJ.

AMP ADJ A

AMP ADJ B

DUTY CYCLE ADJ.

+4.5 V +3.0V OUTPUT

R4 & R5, R55 & R56 ARE RATIO MATCHED PER P00347617-1502

(-13.5V TO -20.V CONTROLLED BY R2)

CLOCK REF 1XX

DATE INPUT

TRIGGER 4XX

TRIGGER INPUT

TRIGGER LEVEL R1

(+10V TO +20V CONTROLLED BY R1)

MANUAL S10

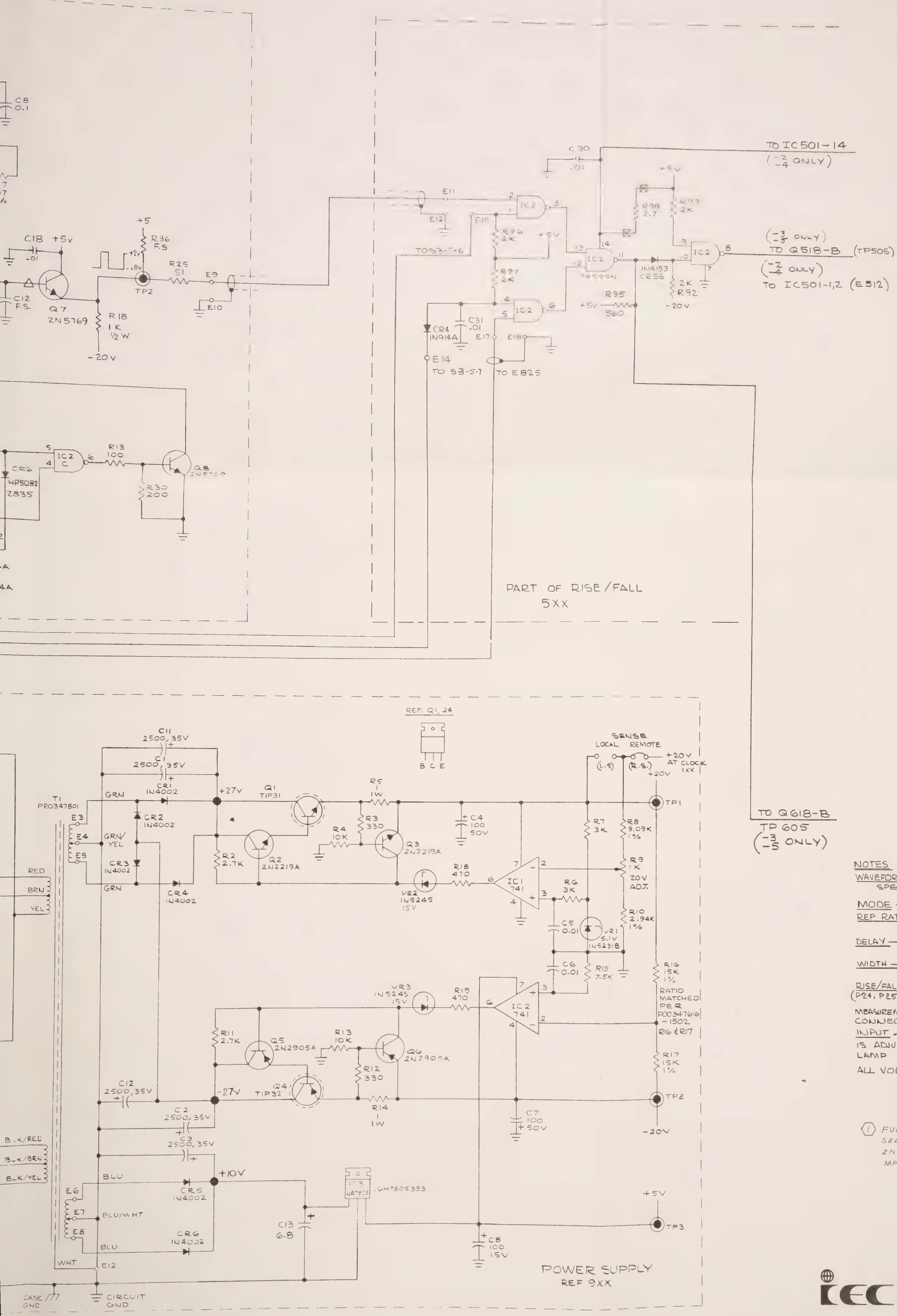
SLOPE SELECT S9

+6V +4V

+.6V -.6V

+.3V -.3V

+20V
CR1 IN4153
R1 1K MIN ADJ.
R2 1.10K 1% +10V TO +20V CONTROLLED BY R4
C13 0.01
R23 120K
CW MAX DELAY
R4 100
DELAY VERNIER R3 5K
E1 E2 E3 CW CCW
Q1 2N3251
C14 0.01
R6 3.3K
R3 4.32K 1%
+20V MAX DELAY ADJ.
R8 50K
R5 150K
C3 0.0047
C4 .47
C5 47
+5V
R7 390
C6 0.1
Q5 2N3904
Q6 2N5771
C12 0.01
Q4 2N3904
TP1
C2 2.3-20PF
R24 560
TP-3 +4V +3.4V
R14 49.9 1%
R22 178 1%
C17
R21 500
C7 0.01
R13 1.00K 1%
R16 910 1/2W
R20 1470 1%
C8 0.1
C9 0.01
R9 200 1%
CR2 IN4153
L1 .15μh
R15 68
Q2 2N4238
Q3 2N4258
CR3 IN4153
R17 107 1%
R12 309 1%
C10 0.01
C16 0.01
R36 F.S
R25 5
TP2 +2.1V -.5V
Q7 2N5769
R18 1K 1/2W
-20V
10ns 1μs 100μs 10ms 1S
S5-A S5-B
DELAY RANGE SWITCH S5
C11 2.3-20PF
R11 10K
R19 200
Q8 2N5769
Q9 2N5769
TP G
CR4 IN914A
R10 2K
E10 E9
DELAY INPUT
DELAY REF 2XX
+20V
R1 1K
CR1 IN4153
C11 0.01
R2 1.10K 1%
CW E1 E2 E3 CCW
R4 100
WIDTH VERNIER R4 5K
TO S3-4-6
C14 0.01
Q1 2N
R6 3.3K
R3 4.32K 1%
+5V
R7 390
C6 0.1
10ns 1μs 100μs 10ms 1S
S6-A
TO S3-5-7
WIDTH RANGE SWITCH S6
WIDTH REF 3XX
+5V
R44 2.7
R48 56
E28 TO S3-1-6
R26 560
R3 47
E24 E23
TP 1
IC1 74S00N
R39 560
+3.6V +.3V
+5V
E29 JUMPER E9 E8
IC5 2N74S04N
R24 2.7
DELAY CIRCUIT
C4 .1 MF
IC6 SN74S04N
R51 R52 R53 R54 R55 R56 560Ω
E1 TO S3-3-1
R17 2.2K
4.3K R18
E13 E12 TO E109 E25 TO E517 E26
R46 47
TP3 (+.2V)
R47 47
TP2 (+3.7V)
R22 2K
IC2 IC3 IC4 SN74S00N SN7400N
+5V R38 560
+3.5V +.5V
R5 560
R6 18
Q5 P00347002
C1 .01
C17 .01 MF
CR3 IN4153
CR12 IN4153
CR4 IN4153
C6 .01 MF
R7 1.3K 1/2W
R8 47 1/2W
E19 E20
-20V
CLOCK OUT J2
+2.5V -.2V
+5V
R25 18
560 R23
+1.0V +1.0V
Q8 P00347002
C13 .01
CR6 IN4153
C10 .01 MF
IN4153 CR7
IN4153 CR8
C11 .01 MF
R27 1.3K 1/2W
R28 47 1/2W
E14 E15
-20V
SYNC OUT J3
+3.0V .0V
+20V
Q11 2N3251A
CR10 IN914A
+5V
R29 200
Q10 2N5769
R31 3.3K
C15 50MF 25V
C14 51PF
R32 330
R35 4.7K
R36 1.2K
C16 .01
C9 .001
Q12 2N5769
TRIGGERED DS2
E21 E22
CR9 IN914A
R30 1.5K 1/2W
CR13 IN914A
R34 10K
-20V
LOGIC REF 8XX
TO E802
TO E308
TO E404
TO E801
TO E803
S3-1
TO E828
TO E412
S3-2
S3-3
TO (TRIGGER LEVEL R1-W)
TO E302
S3-4
TO E402
TO S6-A-W
S3-5
TO E411
MODE SWITCH S3
1 2 3 4 5 6 7
W
1 PULSE AMP
2 GATE
3 TRIGGER
4 TRIGGER
5 DBL. PUL
6 DUTY CYC
7 NORMAL



NOTES

WAVEFORM TEST CONDITIONS : UNLESS OTHERWISE SPECIFIED

MODE —— TRIGGER

REP RATE — 10K Hz – 1M Hz VERNIER @ MIN

DELAY —— 1μS – 100 μS VERNIER @ MIN

WIDTH —— 1μS – 100 μS VERNIER @ MIN

RISE/FALL —— 5 nS — 500 nS
(P21, P25 ONLY) VERNIER @ MIN

MEASUREMENTS MADE W/COAX TEST CABLE CONNECTING CLOCK OUTPUT W/ INPUT. THE LEVEL CONTROL IS ADJUSTED UNTILL TRIGGERED LAMP IS ILLUMINATED.

ALL VOLTAGES ARE NOMINAL VALUES

▷ DENOTES ½ BEAD

⊠ DENOTES FULL BEAD

(1) FULL BEAD USED ON Q111 EMITTER WHEN SELECTED XSISTOR P00347008 IS TYPE 2N3904 OR P00347001. NO BEAD USED WHEN MPS 3711 IS USED.

FS MEANS FACTORY SELECT

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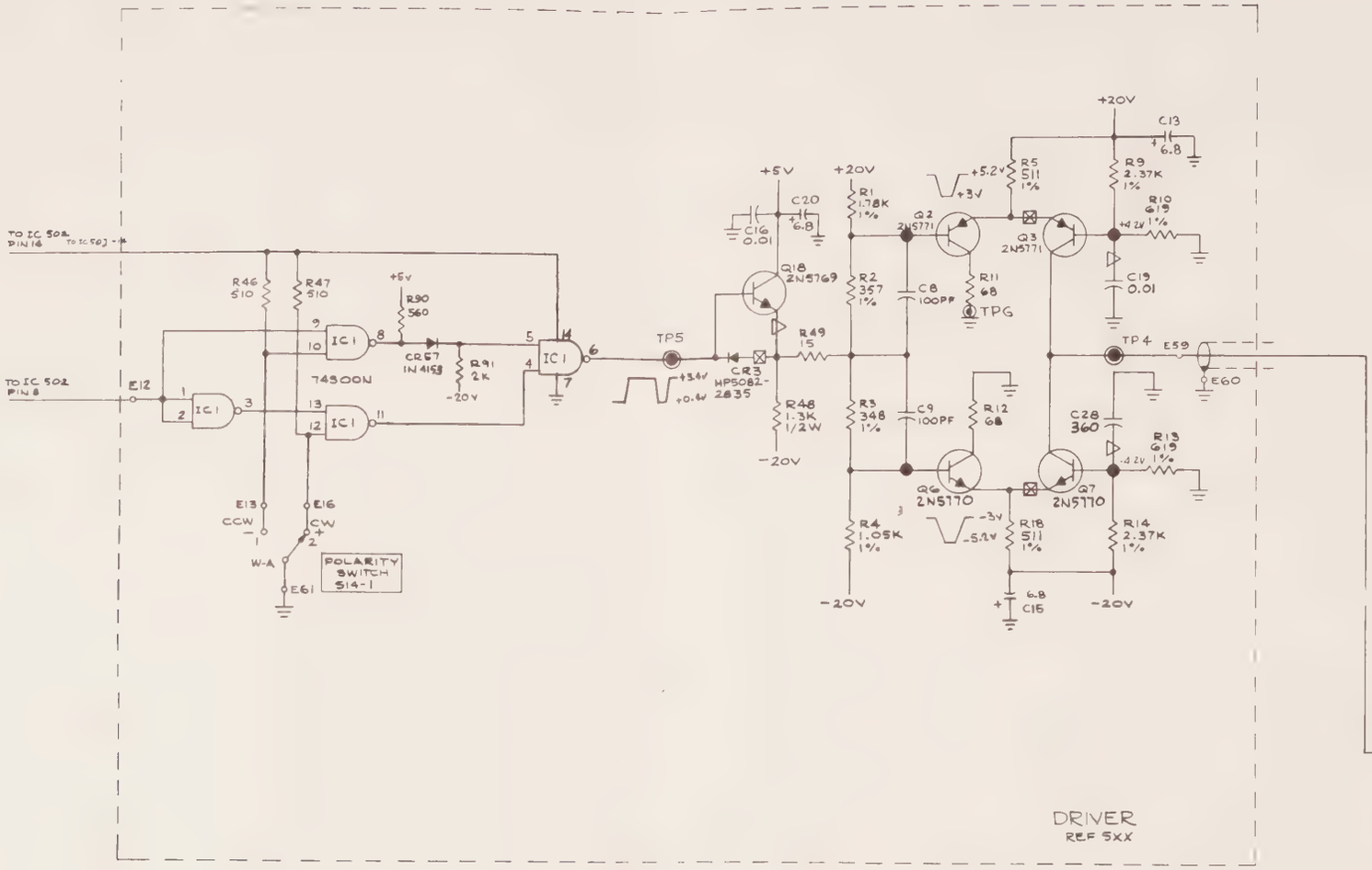
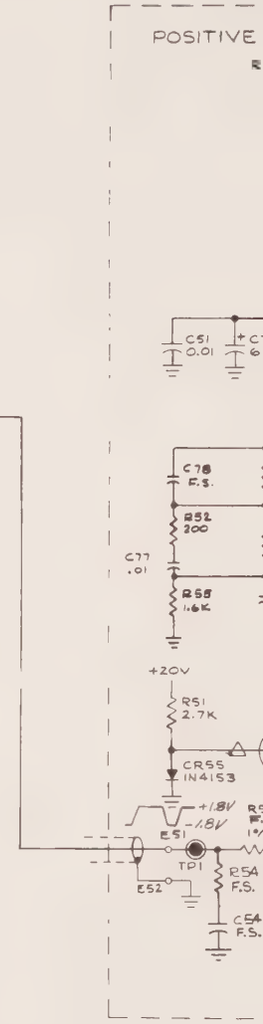
Figure 7-1. SERIES 20 Pulse Generator Input Schematic


TO IC 502 PIN 16
TO IC 502 PIN 8
E12
R46 510
R47 510
+5v
R90 560
IC1
74S00N
CR67 IN4153
R91 2K
-20V
E13
CCW
E16
CW
W-A
E61
POLARITY SWITCH S14-1
TP5
+3.4V
+0.6V
CR3 HP5082-2835
+5V
+20V
C20
C16 0.01
Q18 2N5769
R49 15
R48 1.3K 1/2W
R1 1.78K 1%
R2 357 1%
R3 348 1%
R4 1.05K 1%
C8 100PF
C9 100PF
R11 68
R12 68
Q2 2N5771
Q3 2N5771
Q6 2N5770
Q7 2N5770
+5.2V
+3V
-3V
-5.2V
R5 511 1%
R18 511 1%
C13 6.8
R9 2.37K 1%
R10 619 1%
+4.2V
C19 0.01
TP4
E59
E60
C28 360
R13 619 1%
R14 2.37K 1%
C15 6.8
DRIVER
REF 5XX


POSITIVE
C51 0.01
C78 F.S.
R52 200
C77 .01
R55 1.6K
+20V
R51 2.7K
CR55 IN4153
+1.8V
-1.8V
E51
TP1
E52
R54 F.S.
C54 F.S.

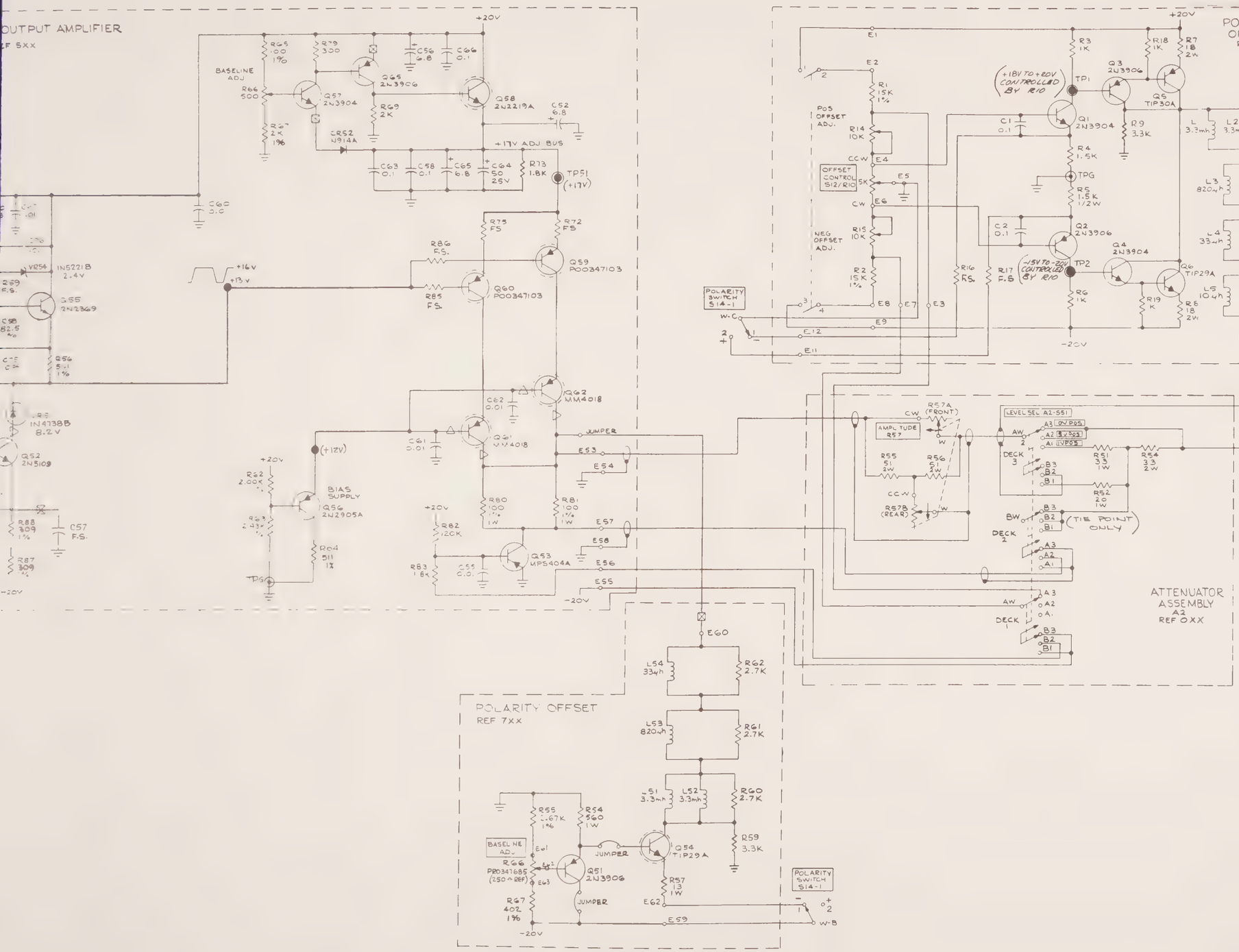


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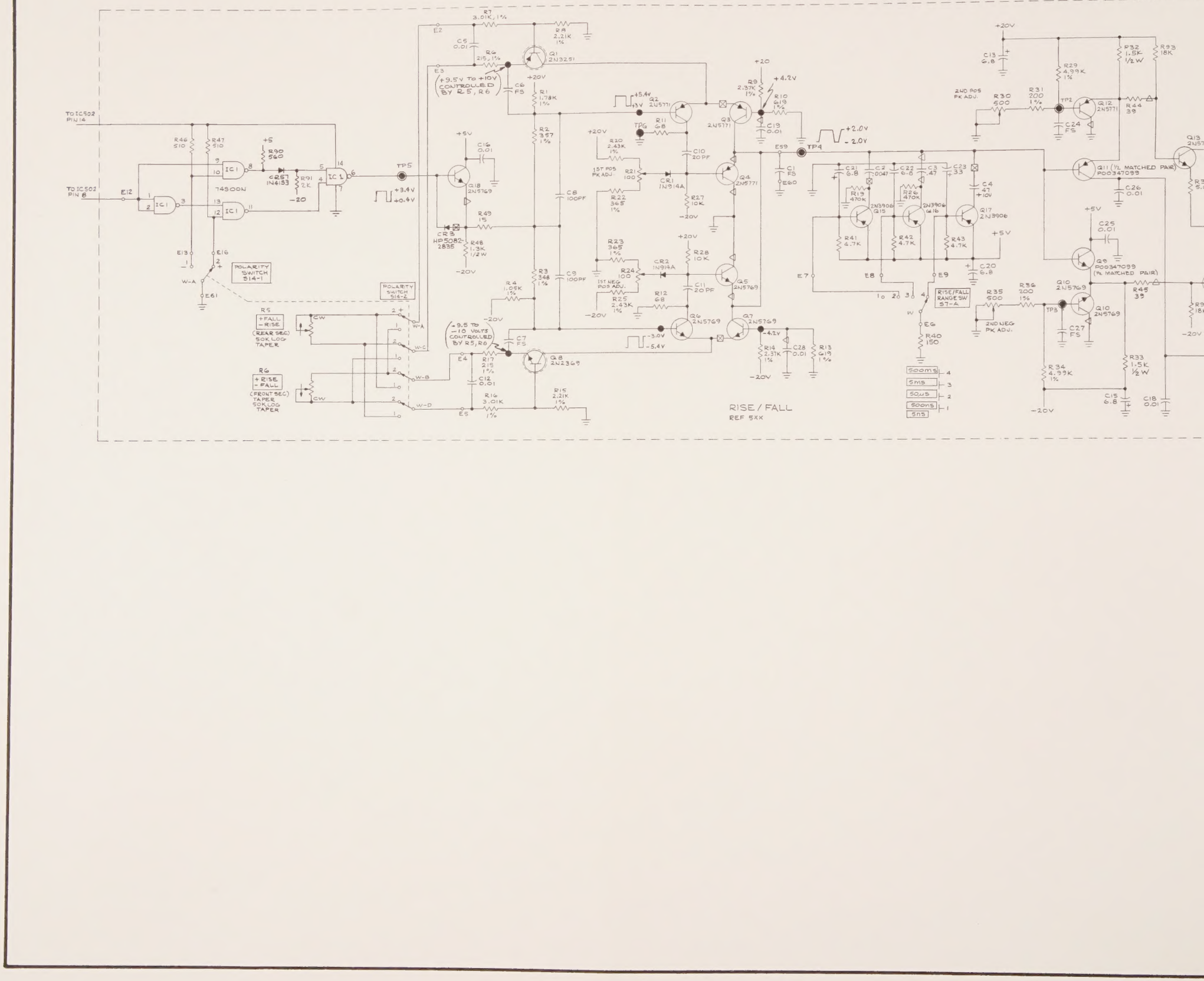
Figure 7-2. Output Section Schematic-P22 Pulse Generator


TO IC502 PIN 14
TO IC503 PIN 8
E12
R46 510
R47 510
IC1
74S00N
+5
R90 560
CR57 IN4153
R91 2K
-20
IC1
TP5
+3.4V
+0.4V
E13
E16
POLARITY SWITCH 514-1
W-A
E61
POLARITY SWITCH 514-2
R5 +FALL -RISE (REAR SEC) 50K LOG TAPER
R6 +RISE -FALL (FRONT SEC) TAPER 50K LOG TAPER
CW
W-A
W-C
W-B
W-D
E5
E4
R7 3.01K, 1%
R8 2.21K 1%
C5 0.01
R6 215, 1%
E2
E3
(+9.5V TO +10V CONTROLLED BY R5, R6)
Q1 2N3251
C6 FS
R1 1.78K 1%
R2 357 1%
C8 100PF
C9 100PF
R3 348 1%
R4 1.05K 1%
C16 0.01
Q18 2N5769
R49 15
CR3 HP5082-2835
R48 1.3K 1/2W
-20V
(-9.5 TO -10 VOLTS CONTROLLED BY R5, R6)
C7 FS
Q8 2N2369
R17 215 1%
C12 0.01
R16 3.01K 1%
R15 2.21K 1%
+5.4V
+3V
Q2 2N5771
TP6
R11 68
+20V
R20 2.43K 1%
1ST POS PK ADJ.
R21 100
CR1 1N914A
C10 20 PF
R27 10K
-20V
R22 365 1%
R23 365 1%
R24 100
1ST NEG POS ADJ.
R25 2.43K 1%
CR2 1N914A
R28 10K
C11 20 PF
R12 68
Q6 2N5769
Q7 2N5769
-3.0V
-5.4V
+20
+4.2V
R9 2.37K 1%
R10 619 1%
C19 0.01
Q3 2N5771
Q4 2N5771
Q5 2N5769
+2.0V
-2.0V
TP4
E59
C1 FS
E60
R14 2.37K 1%
C28 0.01
R13 619 1%
-4.2V
C21 6.8
C22 .0047
C23 .33
C2 6.8
C3 .47
C4 .47 +10V
R19 470K
R26 470K
2N3906 Q15
2N3906 Q16
Q17 2N3906
R41 4.7K
R42 4.7K
R43 4.7K
C20 6.8
+5V
E7
E8
E9
1 TO 2 3 TO 4
RISE/FALL RANGE SW S7-A
W
E6
R40 150
50ms 4
5ms 3
50µs 2
500ns 1
5ns
RISE / FALL
REF 5XX
+20V
C13 6.8
R29 4.99K 1%
240 POS PK ADJ.
R30 500
R31 200 1%
TP2
R12 2N5771
C24 FS
R32 1.5K 1/2W
R93 18K
R44 39
Q11 (½ MATCHED PAIR) P003470B9
C26 0.01
C25 0.01
Q9 P003470B9 (½ MATCHED PAIR)
R35 500
R36 200 1%
2ND NEG PK ADJ.
Q10 2N5769
TP3
C27 FS
R45 39
R33 1.5K 1/2W
R34 4.99K 1%
C15 6.8
C18 0.01
-20V

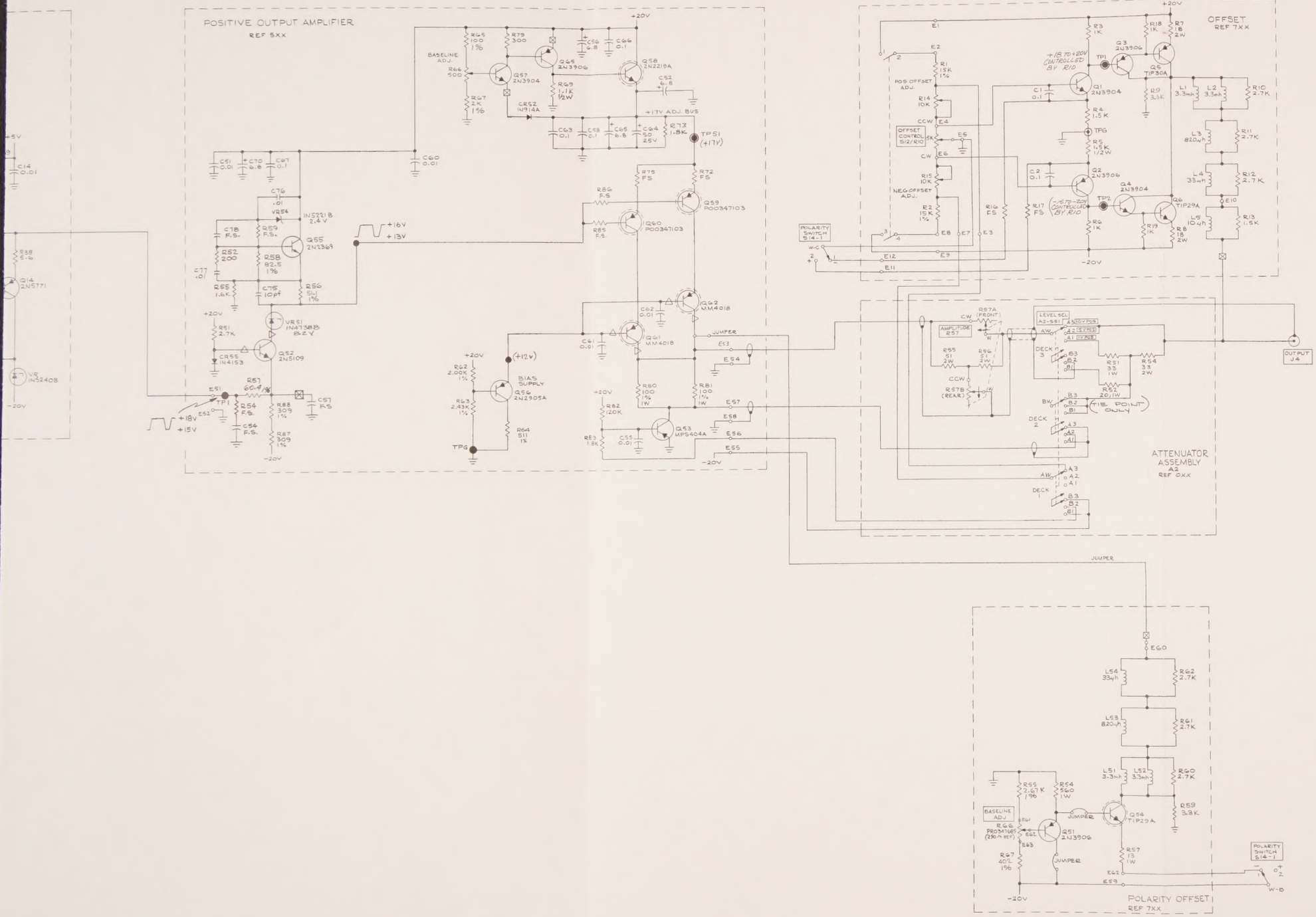


Figure 7-3. Output Section Schematic-P24 Pulse Generator

MP MASTER
MA28120